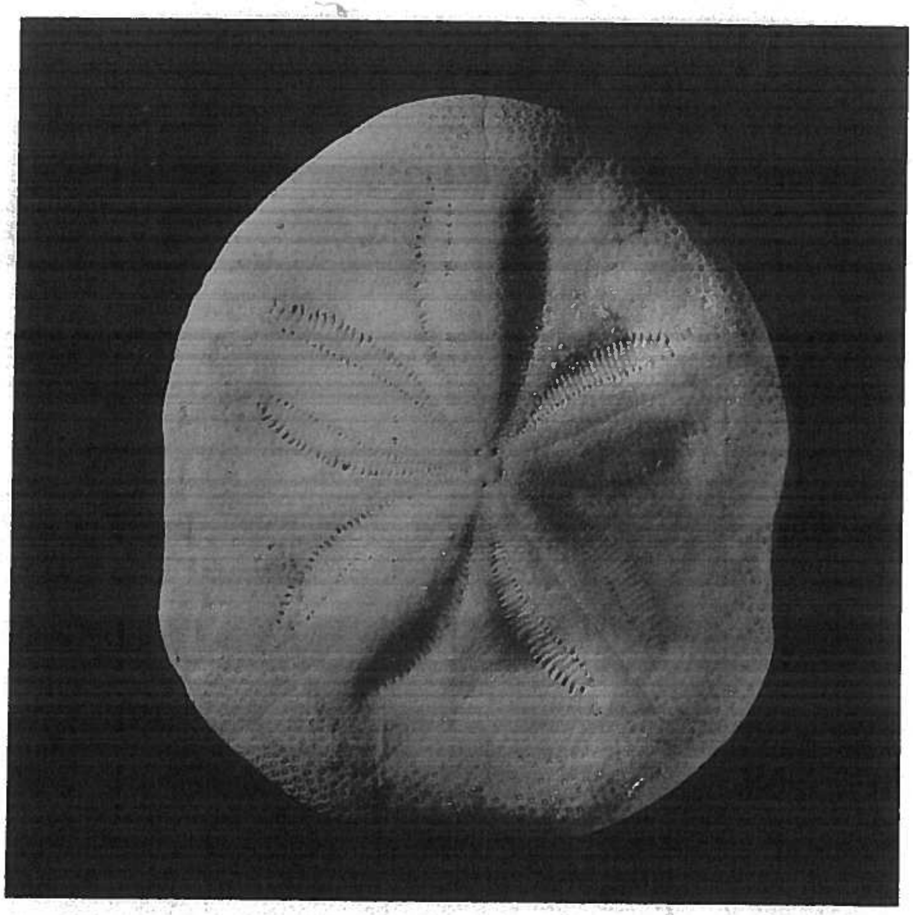
ILLUSTRATED FOSSILS OF THE GEORGIA COASTAL PLAIN



Reprinted by The Georgia Department of Mines, Mining and Geology from Georgia Mineral Newsletter Articles by Dr. H. G. Richards.

Cover shows the Oligocene echinoid Clypeaster rogersi, found in the Byram Formation and Flint River-Suwannee Formation.

INTRODUCTION

This publication is a reprinted collection of papers which Dr. H. G. Richards wrote for the Georgia Mineral Newsletter. The articles were published separately, and have been in such demand that the supply has been exhausted. The reprinting of the articles has been done in chronological order, as follows:

Geologic Age	Chronologic Age
Recent	Present
Pleistocene	to 3,000,000 years before present
Pliocene	to 12,000,000 years before present
Miocene	to 26,000,000 years before present
Oligocene	to 38,000,000 years before present
Upper Eocene	to 45,000,000 years before present
Middle and Lower Eocene and Paleocene	to 65,000,000 years before present
Cretaceous (2 parts)	to 136,000,000 years before present

Each section describes and illustrates the fossil remains of sea-dwelling organisms which have been found in sediments of a particular epoch or period of geologic time on the Coastal Plain of Georgia. For location of other areas of occurrence of these sediments, the reader is referred to the Geologic Map of Georgia (1968) available from the Georgia Department of Mines, Mining, and Geology.

Georgia Sea Shells [1]

by

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The marine invertebrate animals of the Atlantic Coast can be divided into five main zones, separated from each other, in part at least, by natural geographic boundaries. These zones are:

ARCTIC ZONE—Arctic Seas to Gulf of St. Lawrence
ACADIAN ZONE—Gulf of St. Lawrence to Cape Cod
VIRGINIAN ZONE—Cape Cod to Cape Hatteras
CAROLINIAN ZONE—Cape Hatteras to Florida
CARIBBEAN ZONE—Florida Keys, West Indies, etc.

The coast of Georgia lies at about the middle of the Carolinian zone.

[1]Part of this article has been adapted from the book "Animals of the Seashore" by Horace G. Richards. (Bruce Humphries, Boston, 1938).
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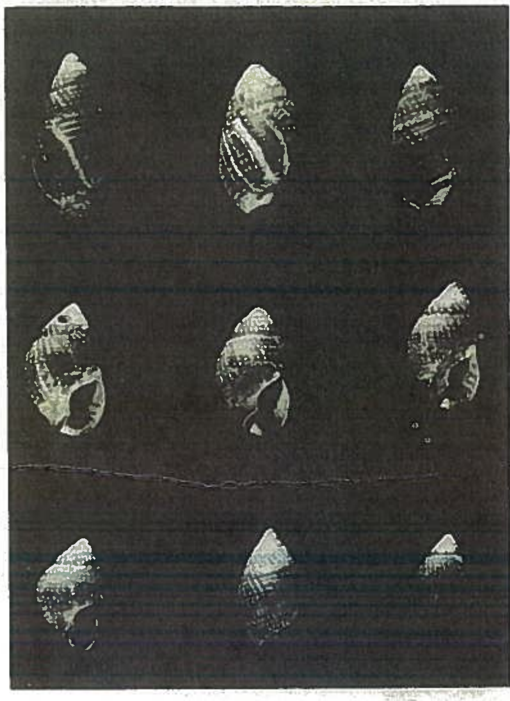
Seashore animals are usually particular about their place of living; some prefer the mud flats of the harbors and bays, while other choose a sandy association; still others require a rocky habitat. Many of these animals have distinct preferences as to depth of water. Some are usually found between the tides, while others prefer the shallow water a little distance off shore. Then there are the deep sea dwellers—those animals that live in the extreme depths of the ocean and which seldom or never are found near shore.

The usual collector is interested in those animals that he can obtain most readily, namely the forms of the intertidal zone, or those of the shallow sea zone which are frequently cast upon the beach by the waves.

Perhaps the best place to obtain a large number of living sea animals is a tidal mud flat such as occurs back of Sea



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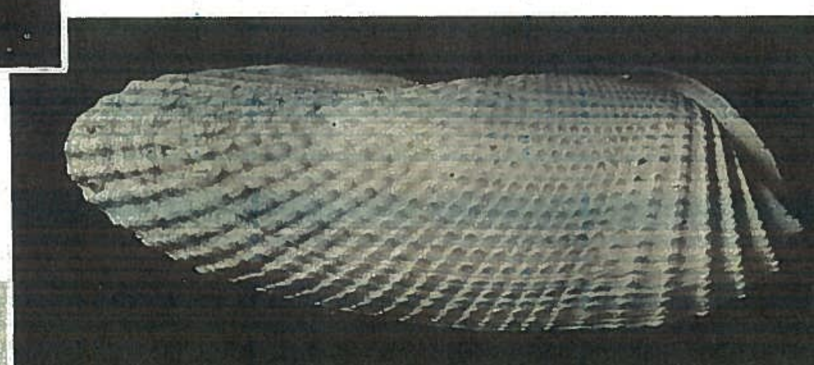

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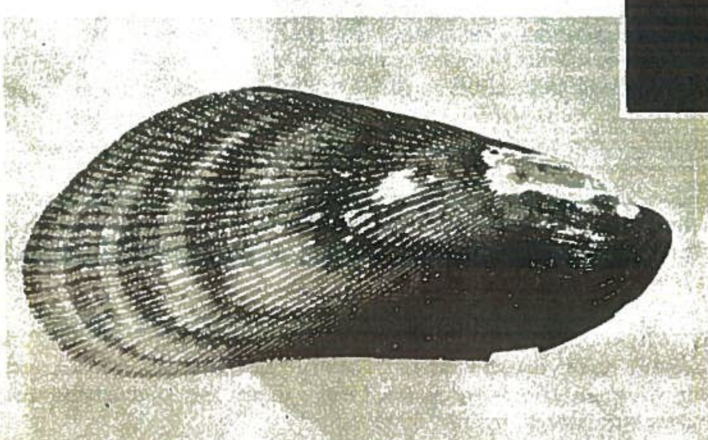

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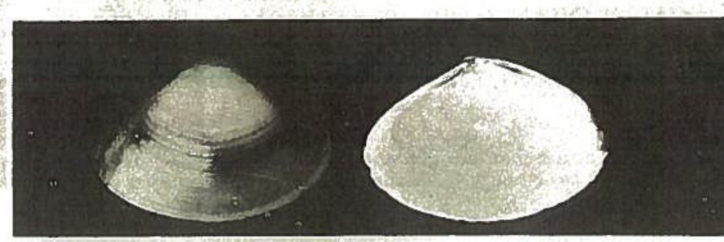

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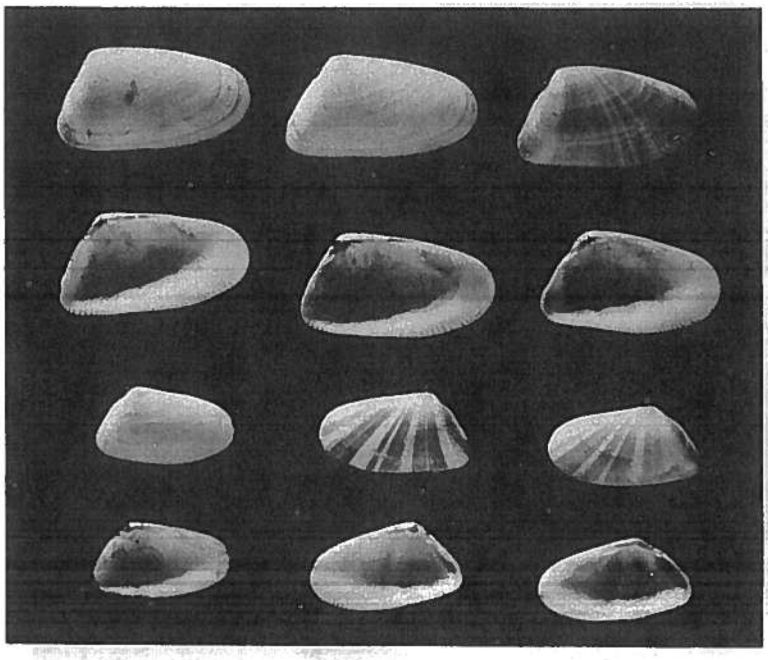
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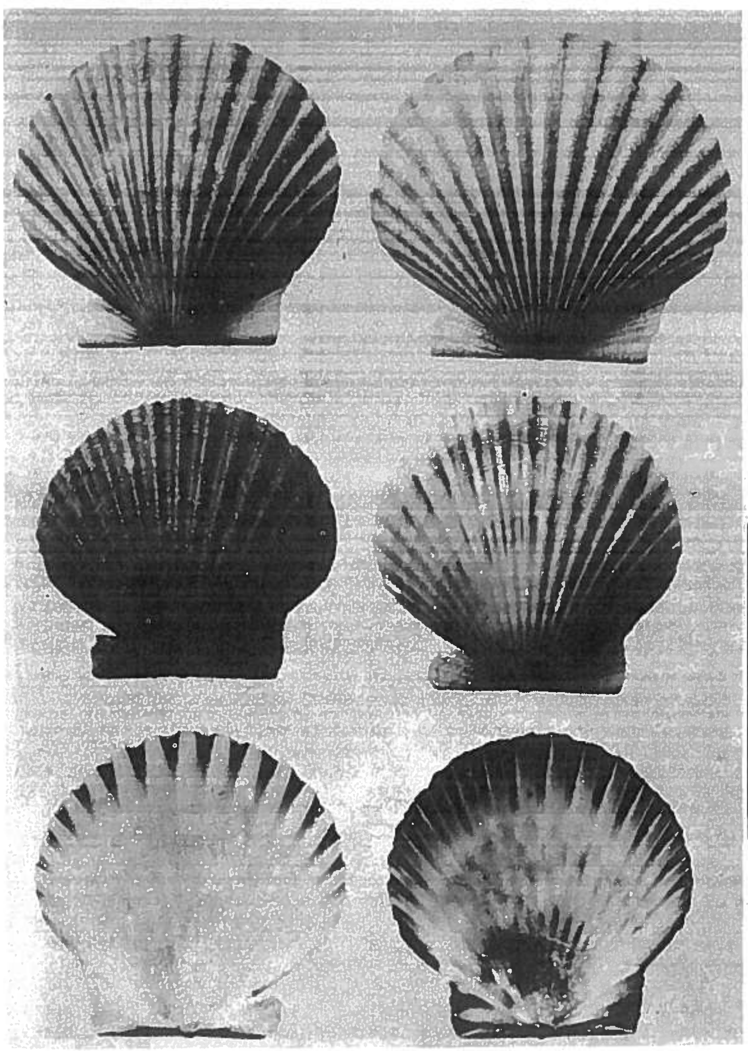
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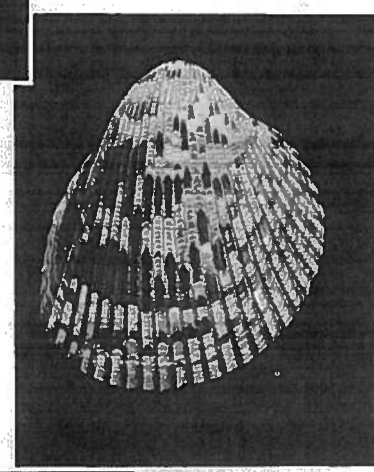
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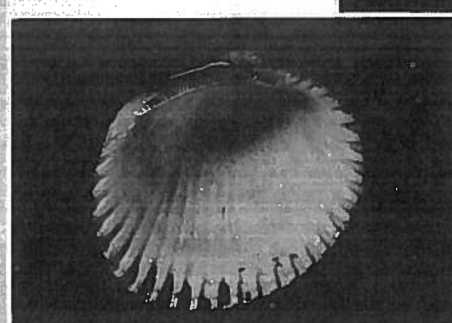
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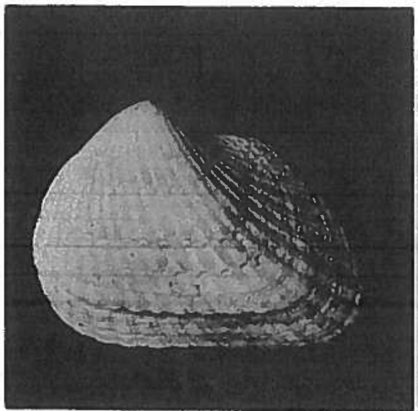
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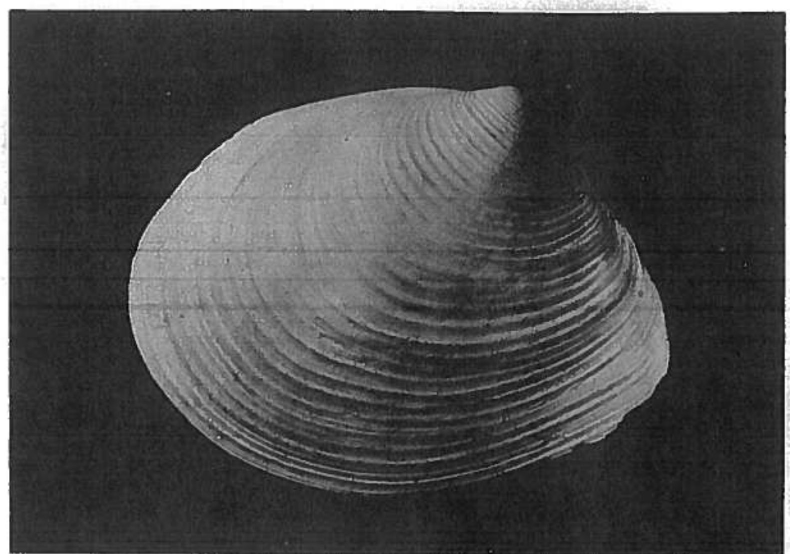
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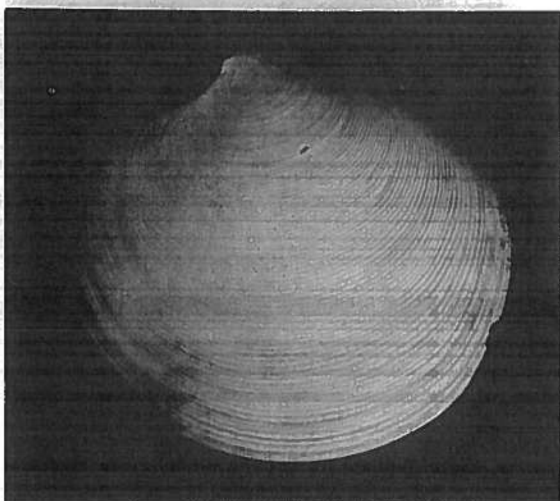
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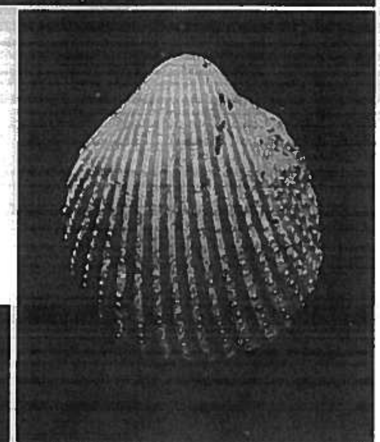
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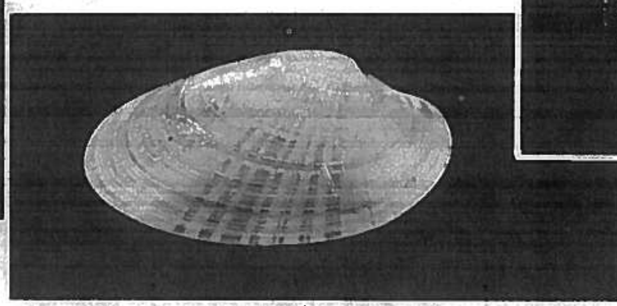
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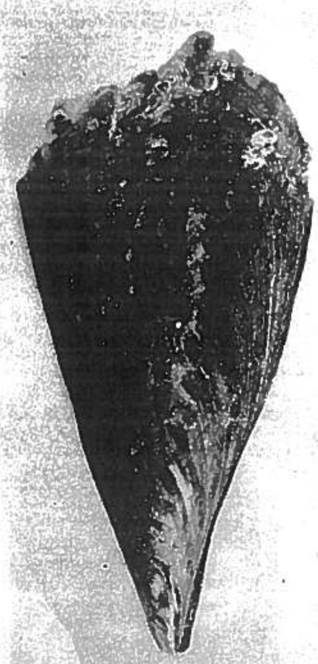
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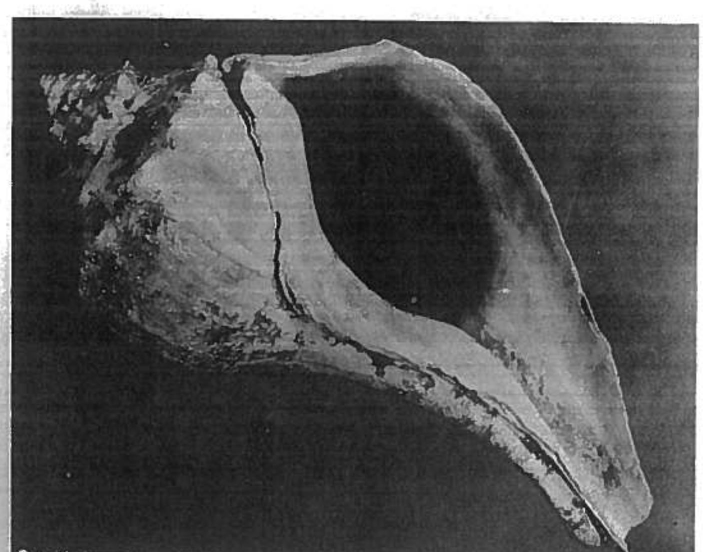
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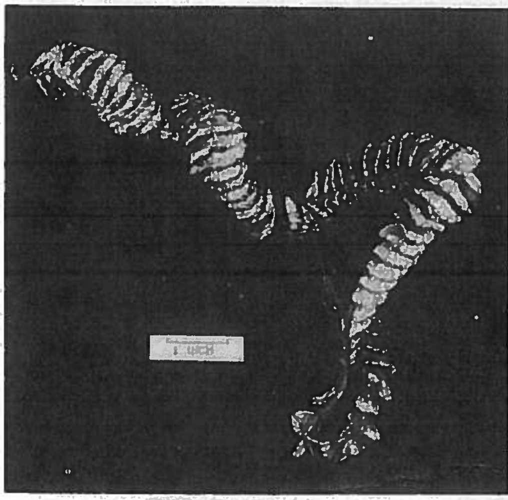

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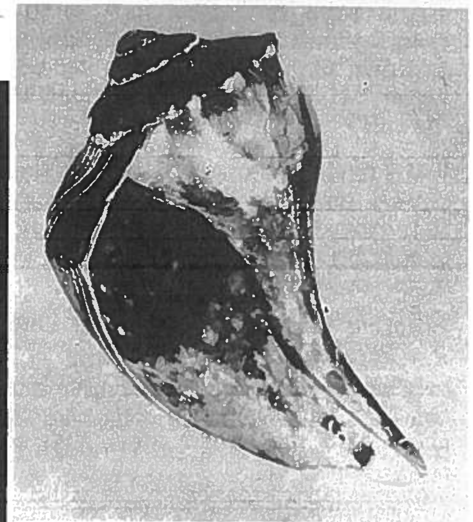

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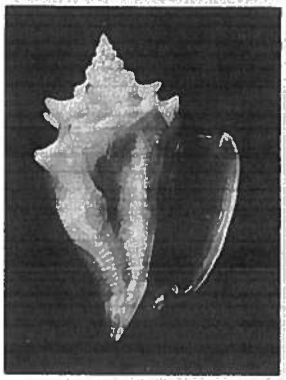

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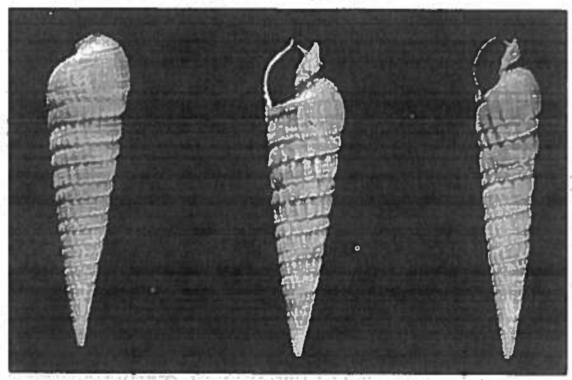

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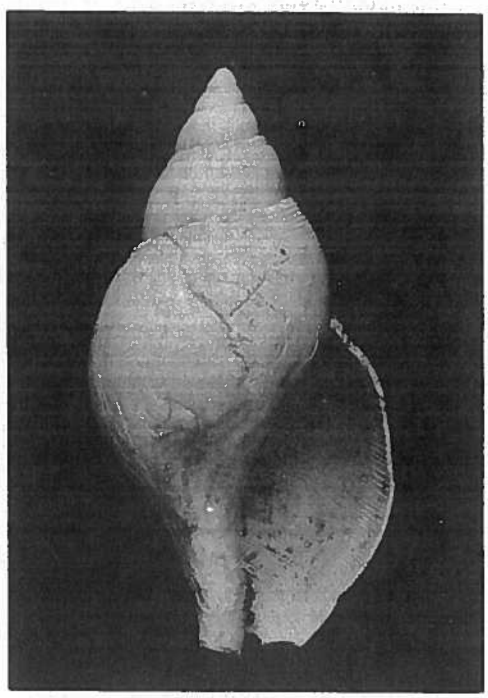

Fig. 31

Fig. 32

Island Beach or Cumberland Island. The soft nature of the mud makes it easy for many species to build their homes. In addition, the mud flats are protected from the action of the waves. It is in such associations that one finds the following:

Nassa obsoleta Say—(Fig. 1, natural size)—Mud Snail

This small black snail is exceedingly abundant on mud flats from between the tides to 2 fathoms and occasionally deeper; usually found in inlets or in brackish water and never in the open ocean.

Littorina irrorata Say—(Fig. 2, natural size)—Salt Marsh Periwinkle

About an inch in height, usually white with a series of brown revolving lines or dots. Found between the tides or above high water mark, often attached to salt marsh vegetation.

Ostrea virginica Gmelin—Oyster

Found between tides and in shallow water, usually where there is considerable mixture with fresh water. Too familiar to require a photograph.

Venus mercenaria Linné—Clam

The common clam is also abundant on many Georgia tidal flats as well as in the shallow water of bays and inlets.

Ensis directus Conrad—(Fig. 3, natural size)—Razor Clam

Shell slightly curved, usually white but covered with an olive green epidermis; up to 6 inches in length. Burrows in the mud flats. The shell is frequently found on the ocean beaches.

Tagelus gibbus Spengler—(Fig. 4, natural size)—Blunt Razor Clam

Less elongate than *Ensis*. Rarely found alive, but common on most beaches.

Anomia simplex d'Orbigny—(Fig. 5, natural size)—Toe Nail; Jingle

Roughly round in shape, up to 3 inches in diameter; varicolored (yellow, silver, gold, black, etc.). Especially characterized by its pearl-like nacre. One valve is flat and there is a large oblong hole near the beak; through this hole projects a calcareous byssus by means of which the shell is attached to an object such as a pebble or another shell. The other valve is curved.

Pholas costata Linné—(Fig. 6, natural size)—Angel Wings

The large Angel Wings reaches as much as 6 inches in length. It burrows two feet or more deep in mud or clay and is seldom seen alive. Frequently found on Georgia beaches along with two other species which somewhat resemble this shell (*Pholas campechiensis* and *Petricola pholadiformis* Lamarck).

Modiolus demissus Dillwyn—(Fig. 7, natural size)—Horse Mussel

Shell up to 4 inches in length and characterized by numerous radiating ribs; epidermis very thin and of pale brown color. Lives in tidal mud flats near high tide line.

A sandy beach is not a good place to look for living sea animals. It is usually difficult for these animals to burrow into the hard sand, and they would consequently be exposed to the force of the waves. Some animals adapt themselves to this environment and can be looked for on sandy beaches. Some worms burrow into the sand between tides while others construct more or less permanent tubes of the sand grains (*Sabellaria vulgaris, Cistenides gouldi*, etc.)

The Sand Crab or Ghost Crab (*Ocypoda albicans*) can frequently be seen scurrying along the beach and disappearing into its hole near or above high water mark. The Sand Bug or Hippa (*Emerita talpoidea*) and the Lady Crab (*Ovalipes ocellatus*) burrow into the sand close to low water mark.

Among the shell fish or mollusks that live on sandy beaches may be mentioned the following:

Mactra soladissima Dillwyn—(Fig. 8, natural size)—Surf Clam; Sea Clam

Large shell, up to 7 inches in length, covered with a pale brown epidermis. A small triangular shaped cartilage plate at the hinge is characteristic. Lives at and below low tide line.

Donax variabilis Say—(Fig. 9, natural size)—Wedge Clam; Coquina

Small, up to an inch in length, elongated; very smooth, ornamented with radiating lines. Usually brilliant purple in color, but various shades can be found. Very common on sandy beaches where it may be seen burrowing into the sand at low tide line just as the waves recede.

Polinices duplicata Say—(Fig. 10, natural size)—Moon Snail

Up to 3 inches in diameter, with a comparatively flat apex; light gray to purple in color. Usually found partly buried in the sand from the intertidal zone to relatively deep water.

Many animals of the shallow sea zone and off-shore communities are found on the beach where they have been carried by the waves. If one walks along a Georgia beach after a severe storm, one is apt to find a great variety of sea animals that have been washed, either living or dead, upon the beach. Among the shells that are most frequently found on the Georgia beaches may be mentioned the following:

Pecten gibbus Linné—(Fig. 11, natural size)—Scallop

A fan shaped shell found on most beaches. Often brightly colored. Lives in bays and shallow water of the ocean. The muscle connecting the two valves is highly prized as food.

Chione cancellata Linné—(Fig. 12, natural size)

A small bivalve related to the common clam; distinguished by its characteristic cancellate sculpture.

Cardium robustum Solander—(Fig. 13, about X ½)—Cockle

A large bivalve with conspicuous ribs frequently found on the beach in great numbers.

Arca campechiensis Gmelin—(Fig. 14, natural size)—Ark

Roughly circular in shape; characterized by its long row of comb-like hinge teeth; up to 3 inches in length.

Arca transversa Say—(Fig. 15, natural size) Transverse Ark

Similar to the above, but elongate and with beak more central and not directed foreward.

Arca ponderosa Say—(Fig. 16, natural size)—Large Ark

Larger and thicker than the above with a prominent constriction (or shelf) on each valve.

Labiosa canaliculata Say—(Fig. 17, natural size)

Shell rather similar to *Mactra*, but thinner and ornamented with ribs.

Dosinia discus Reeve—(Fig. 18, natural size)

Hinge rather similar to the common clam (*Venus*). Shell ornamented with many fine concentric lines.

Cardium muricatum Linné—(Fig. 19, natural size)
Smaller than *Cardium robustum,* more elongate, and with spines on the radiating ribs.

Macrocallista nimbosa Solander—(Fig. 20, about X½)—Sun Ray
Elongate, up to 6 inches in length. The ornamentation of the shell suggests the rays of the setting sun.

Atrina rigida Dillwyn—(Fig. 21, X ½)—Pen Shell
Triangular in shape with horny texture and conspicuous spines. Reaches a length of 8 inches. A related form (*Atrina serrata*) is covered with delicate scales instead of the spines.

Fulgur carica Gmelin—(Fig. 22, X ½)—Knobbed Conch
May reach 9 inches in length. Characterized by the knobs on the spire. Egg cases are common on some beaches (Fig. 23).

Fulgur canaliculata Linne—(Fig. 24, X ½)—Channeled Conch
Not as common as the above, and usually somewhat smaller. Note the deeply channeled sutures of the spire.

Fulgur perversa Linné—(Fig. 25, X ½)—Left Handed Conch
Somewhat similar to *Fulgur carica* except that the aperture is on the left side. This form lives from Cape Hatteras southward, while the other two species range all along the East Coast.

Strombus pugilis Linné—(Fig. 26, about X ½)—Giant Conch
More characteristic of Florida, but often found on Georgia beaches.

Oliva sayana Ravenel—(Fig. 27, natural size)—Olive
This slender tapering shell reaches 2 inches in length. Usually a brilliantly polished light brown. Lives in the sand below low tide line and often found on Georgia beaches.

Terebra dislocata Say—(Fig. 28, natural size)—Spiral
Up to 2 inches in length; note the beaded band on each whorl.

Sinum perspectivum Say—(Fig. 29, natural size)—Ear Shell
White in color, roughly resembling an ear—hence its name. The animal is not covered entirely by the shell. About 1 inch in diameter.

Marginella guttata Dillwyn—(Fig. 30, natural size)—Spotted Marginella
This beautiful pink shell lives off shore and is rarely washed onto the Georgia beaches.

Fasciolaria tulipa Linné—(Fig. 31, natural size)—Tulip Shell
Reaches a length of 6 inches or more and is usually dark brown in color. A related form (*Fasciolaria distans* Lamarck) has dark brown or black circular bands.

Crepidula fornicata Linné—(Fig. 32, natural size)—Boat Shell
The top of the shell is rounded giving it a boat-like appearance. A shelf covering the upper part of the aperture corresponds to the forecastle of a ship. These shells attach to other shells, stones and frequently to each other. A flat, white species (*Crepidula plana* Say) attaches to flat objects such as the inside of large conchs, while a small convex species (*Crepidula convexa* Say) usually attaches to pebbles.

By no means all the sea shells of Georgia beaches—not even all the common ones—have been discussed in this article. A visitor to one of the beaches after a heavy storm will find many unusual specimens. Perhaps a later article will treat of some of these rarer species.

The Pleistocene of Georgia

by

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FOREWORD

This is the first of a series of articles on the geology and paleontology of the Coastal Plain of Georgia. In a sense, it follows the article on the modern sea shells of Georgia which appeared in the summer number of the News Letter. We will attempt to trace backwards the geological history of the Georgia Coastal Plain. This is, admittedly, somewhat unorthodox, but has an advantage in proceeding from the known (Recent) into the unknown. It will also be possible to compare the modern sea shells with those of the geologic past, again proceeding from the known to the unknown.

No attempt will be made to write a complete geological survey of the Coastal Plain. Several such works are available. Instead, we will attempt to summarize the main geological events of the different periods or epochs, point out a few localities where fossils can be found today, or where they have been found recently, record and illustrate a few of the characteristic fossils, and give references where the more serious student can find further information.

The series will be based upon a survey of the literature, previous work of the present author, and a limited amount of field work sponsored by the Department of Mines, Mining and Geology of the State of Georgia. These field trips were taken in April and September, 1954. The author is indebted to Captain Garland Peyton and Dr. A. S. Furcron for organizing this project and for advice during the course of the investigation. For information on specific localities, he is indebted to various individuals, including the following: Dr. Stephen M. Herrick of the United States Geological Survey in Atlanta, Georgia; Dr. C. Wythe Cooke, United States Geological Survey, Washington, D. C.; and Dr. Katherine V. W. Palmer, Paleontological Research Institution, Ithaca, New York. Mr. James Ruhle assisted in the field work and in the study of the fossils.

The series will include discussions of the following periods or epochs: (youngest to oldest).

Epoch	Years ago to beginning
PLEISTOCENE	1,000,000
PLIOCENE	12,000,000
MIOCENE	20,000,000
OLIGOCENE	40,000,000
EOCENE	60,000,000
PALEOCENE	70,000,000
CRETACEOUS	130,000,000

The first part of this series, that on the Pleistocene, is partly based on field work sponsored by the Geological Society of America in 1935. The interpretations, however, take into consideration work done subsequent to that time.

Some installments will be devoted to a single epoch, and others will include more than one epoch.

THE PLEISTOCENE EPOCH

The Pleistocene, or Quaternary, is the most recent episode in the geologic chornology. Although very brief in comparison with the older periods, it was one of the critical times in the history of the earth. Despite the fact that the Pleistocene is often spoken of as the "Great Ice Age", we know that the climate was not always cold. Immense ice sheets or glaciers covered the northern part of the United States and most of Canada at least four times during the Pleistocene. However, these glacial advances (stages) were separated from each other by three major interglacial stages, much longer in duration than the glacial stages when the climate was at least as warm as that of today.

Suggested correlations of Pleistocene formations of Georgia.

Stage of Pleistocene	Georgia Formations	
Post-Wisconsin	Dahlonega fossils	
Wisconsin glacial	Pamlico formation	
Sangamon interglacial	Talbot (?)	
	Horry clay (South Carolina)	
Illinoian glacial	(Penholoway formation)	"Higher Terraces"
Yarmouth interglacial	(Wicomico formation)	
Kansan glacial	(Sunderland formation)	
Aftonian interglacial	(Coharie formation)	
Nebraskan glacial	(Brandywine formation (?))	

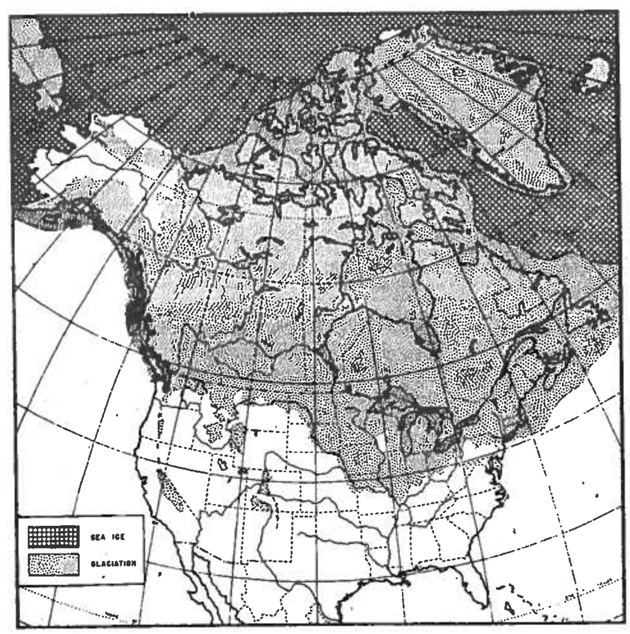


Figure 1. Map showing extent of Pleistocene glaciation in North America. (From "Record of the Rocks" by Horace G. Richards, courtesy Ronald Press.).

*Also, University of Pennsylvania.

There is no evidence that the Pleistocene ice ever reached as far south as the present State of Georgia; in fact, the terminal moraine, or farthest advance of the ice, lay some 300 miles north of this State. (See Figure 1). However, there are various ways in which the Pleistocene glaciers affected the geological history of Georgia.

It has been demonstrated that the great glaciers which covered the northern part of our continent were as much as a mile in thickness. One will readily agree that this is a great deal of ice, which in turn is equivalent to a great deal of water. It is obvious that this water must have originally come from the sea. The normal cycle of precipitation and evaporation was broken, causing this water to be "locked up" in the form of ice. By a mathematical process one can estimate how much water was removed from the sea at the climax of the various glacial stages. Thus, we suppose that the sea level at the climax of the last (Wisconsin) glacial stage was some 300 feet lower than at present and that the Georgia shore line was many miles farther east than it is today.

Conversely, during the various interglacial stages, sea level was higher than at present (because of the melting of the glaciers). During the last (Sangamon) interglacial stage, sea level was probably about 30 feet higher than at present and evidences of this shore line can be seen at various places from Long Island to Florida.

If the rise and fall of sea level due to the advance and retreat of the ice (glacial control) were the only factors involved in Pleistocene history, it would be relatively easy to correlate the Pleistocene shore lines of the world. However, there are other ways in which the glacial ice affected the continents. The great weight of the ice caused the land to be depressed, while the release of the ice caused a subsequent rise. Evidence of this depression and rise can be seen today in the form of raised beaches of ancient shore lines in New England, eastern Canada, Scandinavia, and other glaciated parts of the world. Obviously, no such late-glacial shore lines can be seen in Georgia.

Other geological events may have complicated Pleistocene history. Earth movements, either uplift or subsidence, quite irrespective of the effect of the ice, may have complicated or obliterated the shore lines caused by glacial control. For example, the coasts of California and eastern Cuba have risen, and are still rising, while the coast of Southern Louisiana is sinking; in both places, it is difficult to interpret Pleistocene history.

Along the Atlantic Coastal Plain from New Jersey to Florida, there is a series of deposits, frequently called terraces, which occur at various elevations, up to 300 or more feet above the sea. Some geologists have interpreted these as representing the various interglacial shore lines. The lowest terrace deposit (25 feet) contains abundant marine fossils and thus may well represent the Sangamon interglacial. However, the lack of marine fossils in the higher terraces leaves their marine origin open to question.

Pleistocene History of Georgia

Early Pleistocene. The details of the early Pleistocene history of Georgia have not yet been worked out. The various terrace deposits above the 25 foot level have been referred to the early and middle Pleistocene, but their exact correlation is uncertain. Cooke (1943) in his summary of the geology of the Coastal Plain of Georgia lists the following:

Brandywine	270 feet	Penholoway	70 feet
Coharie	215	Talbot	42
Sunderland	170	Horry	sea level
Wicomico	100	Pamlico	25

Deposits of all but the Horry are known from Georgia. Cooke has suggested that these terraces are of marine origin and represent various interglacial states (sometimes more than one shore line or terrace to an interglacial). Other workers have questioned the marine character of the terraces and believe that the terraces above the 25-foot level are largely of fluviatile origin. (See Flint, 1940.)

On the other hand, MacNeil (1950) recognizes four marine shore lines in Florida and Georgia, as follows:

Name	Elevation	Age
Okefenokee [Sunderland]	150 feet	Yarmouth interglacial
Wicomico	100 feet	Sangamon interglacial
Pamlico	25-35 feet	Mid-Wisconsin glacial recession
Silver Bluff	8-10 feet	Post-Wisconsin

The writer believes that most of the Pleistocene deposits found higher than the 25-foot level (Pamlico shore line) in Georgia are non-marine in origin. Dr. Stephen Taber in a paper, presented before the Southeastern Section of the Geological Society of America at Columbia, South Carolina, in April, 1954, showed evidence that there had been two Pleistocene submergences in South Carolina, one of which he dates from the early Pleistocene and the other of which—a later one (Pamlico)—he correlates with the last interglacial stage.

The writer suggests that the Pleistocene material referred by Cooke to the formations between the Brandywine and the Penholoway (or possibly the Talbot) represents the interval from the beginning of the Pleistocene through the Yarmouth interglacial stage. (The Brandywine may well be Pliocene).

Illinoian Glacial Stage. The Horry clay of South Carolina probably was deposited at a low sea level stage contemporaneous with the Illinoian glaciation. An extensive fauna of mammals including the mammoth, mastodon, bison, horse and camel, has been found on the beaches of South Carolina and has been referred to this stage by Dr. Taber. (personal communication). It is possible that some of the fossil mammal remains found at Brunswick, Ga., here referred to the Wisconsin, may date from the Illinoian glaciation.

Sangamon Interglacial Stage. The deposits of the 25-foot shore line are referred to the last major interglacial stage, the Sangamon. The formation is known as the Pamlico and contains an abundant fauna of marine mollusks. The shore line of the Pamlico sea is shown in Figure 2. The Pamlico formation occupies a 20 mile wide belt from the coast of Georgia to the old 25-foot shore line. Estuarine phases of the formation extend up the main valleys. The Pamlico formation is correlated, in part at least, with the Anastasia of Florida, the Talbot of Maryland and the Cape May of New Jersey. MacNeil (1950) dates the Pamlico shore line from the "mid Wisconsin glacial recession"; however, from investigations of this problem, especially north of Georgia, the present author prefers to date this shore line from the Sangamon interglacial stage.

Wisconsin Glacial Stage. Sea level fell during Wisconsin

time and any evidences of the shore line would have to be searched for beneath the present sea.

However, evidences of Wisconsin land life can be found in Georgia. On Skidway Island, Chatham County, Ga., bones of the Giant Ground Sloth **Megatherium** were found as long ago as 1823. Mammal remains have been found elsewhere in Georgia, the most extensive collection having come from excavations for the Brunswick Canal. At this latter locality, fossil remains of the Elephant, Mastodon, Giant Beaver, Buffalo, three kinds of Horses, two Ground Sloths, Crocodiles and Fishes, have been found.

These fossils have been regarded as contemporaneous with those of the Melbourne Bone Bed of Florida which have been correlated with the Wisconsin glacial stage. It is also possible that some or all of these fossils may date from the Illinoian glacial stage and thus correlate with the bone bed of the Horry clay of South Carolina.

Evidence for a slightly cooler climate in Georgia has been offered by Paleobotanical studies of Penhallow (1905) near Dahlonega, Lumpkin County, Ga. He reported the remains the Larch (**Larix lariciha**) which now has a southern limit, some distance north of Georgia. The exact age of the Dahlonega deposit is uncertain, but it may represent Wisconsin time.

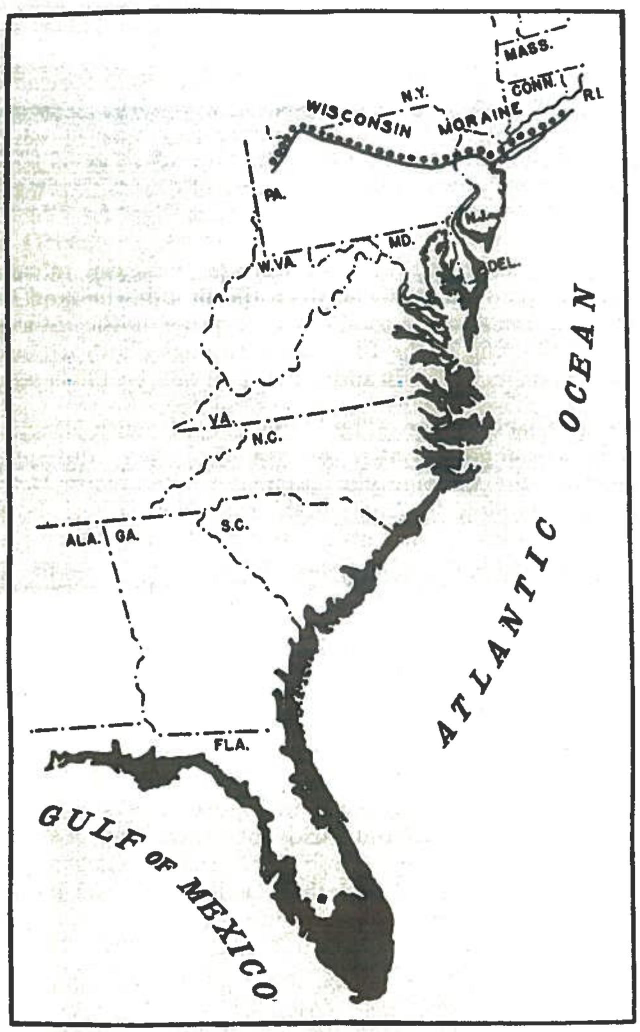


Figure 2. Shore line of the Pamlico formation, which dates from the last interglacial stage about 100,000 years ago.

Post-Wisconsin. There is evidence in various parts of the world that there was a temporary rise of sea level during the "climatic optimum" which occurred about 4000 to 6000 years ago. According to McNeil the 8 to 10-foot Silver Bluff shore line may date from this stage.

PLEISTOCENE FOSSIL LOCALITIES IN GEORGIA

Sands or clays of the "Higher Terraces" of early and middle Pleistocene age overlie Tertiary and Cretaceous deposits in many parts of the State, but, as far as is known, no fossils have been found.

Pamlico Formation

1. **Isle of Hope, Chatham County.** A few poorly preserved fossil oyster shells have been found along Skidway River near Isle of Hope. They are overlaid by shells of recent age.

2. **Savannah River, Chatham County.** Numerous Pleistocene shells have been dredged by the United States Army Engineers from the Savannah River below Savannah.

3. **Savannah, Chatham County.** Earlier writers (Veatch and Stephenson, 1911, and others) report Pleistocene fossils from road sites and shallow excavations near Savannah. No fossil outcrops are known today, the only Pleistocene fossils obtained recently having come from well samples.

4. **St. Marys River, Camden County.** Although fossils have been reported on the south side of the river, in Nassau County, Florida, none has been reported on the Georgia side. The two best localities are (a) Rose Bluff, on the south bank of Bell River, a branch of the St. Marys, three miles southwest of St. Marys, Georgia, and (b) Reeds Bluff, south side of St. Marys River, two miles above Bell River. Some 28 species of mollusks have been found at Rose Bluff while five species occur at Reeds Bluff. (Richards, 1938).

FOSSIL MOLLUSKS

While only 15 species have been found in the Pleistocene deposits of Georgia, mostly near Savannah, a much more extensive fauna is known to occur in both South Carolina and Florida, and presumably lived in the Pleistocene seas of Georgia. Practically all species known from the Pleistocene of Georgia and adjacent states are still living in the ocean, although a few lived a little farther south than they do today. For complete list see Richards (1936). Among the species collected in Georgia—or across the St. Marys River in Nassau County, Florida—are the following

Pelecypoda*

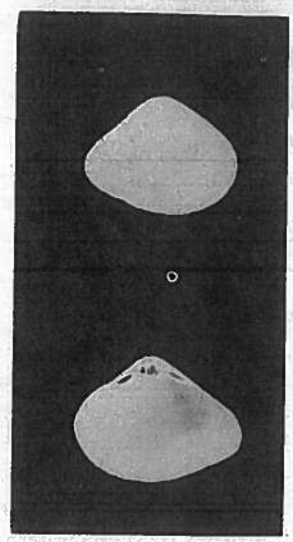
Arca ponderosa Say .... Vol. 7, No. 2, Fig. 16*
Arca incongrua Say .... Fig. 3, 4 X1
Arca transversa Say .... Vol. 7, No. 2, Fig. 15
Ostrea virginica Gmelin ....
Arca campechiensis Gmelin .... Vol. 7, No. 2, Fig. 14
Cardium robustum Solander .... Vol. 7, No. 2, Fig. 13
Venus mercenaria Linne ....
(Common clam)
Venus campechiensis Gmelin .... Fig. 5XI
Chione cancellata Linne .... Vol. 7, No. 2, Fig. 7
Dosinia elegans Conrad ....
Anomia simplex d'Orbigny .... Vol. 7, No. 2m, Fig. 5
Donax variabilis Say .... Vol. 7, No. 2, Fig. 9
Mulinia lateralis Say .... Fig. 6, 7 XI
Labiosa canaliculata Say* .... Vol. 7, No. 2, Fig. 17
Divarcella quadrisulcata d'Orbigny .... Fig. 8 XI

*For figures not given in this article see Georgia Mineral News Letter, Vol 7, No. 2, pp. 71-74.

Figure 3

Figure 4

Figure 5



Figures 6 — 7

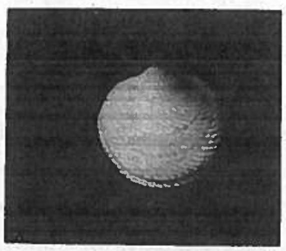


Figure 8

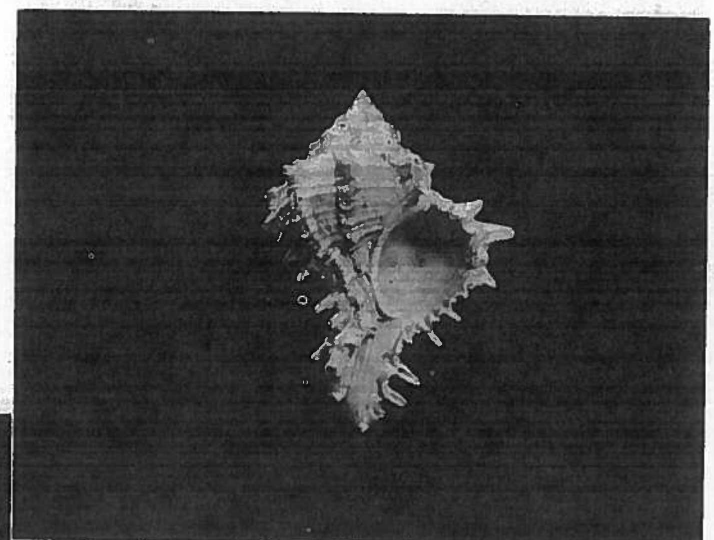
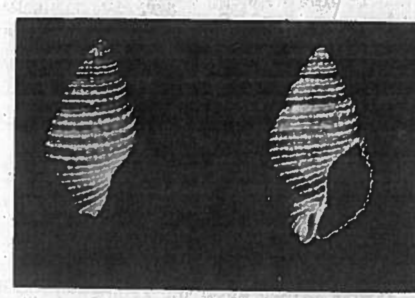


Figure 9

Figure 10

Figure 11



Figures 12 — 13

Gastropoda

Polinices duplicata Say ....Vol. 7, No. 2, Fig. 10

Littorina irrorata Say ....Vol. 7, No. 2, Fig. 2

Murex fulvencens Sowerby ....Fig. 9 XI

Nassa acuta Say ....Fig. 10 X2

Thais floridana Conrad ....Fig. 11 XI

Cantharus cancellaria Conrad ....Fig. 12, 13 XI

Fulgur carica Gmelin....................Vol. 7, No. 2, Fig. 22

Terebra dislocata Say ....Vol. 7, No. 2, Fig. 28

SELECTED BIBLIOGRAPHY

Cooke, C. Wythe 1925 Physical Geography of Georgia; the Coastal Plain. Georgia Geol. Surv. Bull. 42, pp. 19-54.

.... 1943 Geology of the Coastal Plain of Georgia. U. S. Geol. Surv. Bull. 941.

Flint, Richard F. 1940 Pleistocene Features of the Atlantic Coastal Plain. Amer. Jour. Sci. Vol. 238, pp. 757-787.

Hay, O. P. 1923 The Pleistocene of North America and its Vertebrated Animals from the States east of the Mississippi River and from the Canadian Provinces east of Longitude 95. Carnegie Inst. Wash. Pub. 322.

Lyell, Charles A. 1855 A Second Visit to the United States of North America. Vol. 1 (see pp. 313-14)

MacNeil, F. Stearns 1950 Pleistocene Shore Lines in Florida and Georgia. U.S. Geol. Surv. Prof. Paper 221-F.

Penhallow, D. P. 1905 Notes on Tertiary Plants from Canada and the United States. Trans. Royal Soc. Canada. Vol. 10, pp. 57-76.

Richards, Horace G. 1936 Fauna of the Pleistocene Pamlico formation of the southern Atlantic Coastal Plain. Bull. G.S.A. Vol. 47, pp. 1611-56.

.... 1938 Marine Pleistocene of Florida. Bull. G.S.A. Vol. 49, pp. 1267-1296.

.... 1943 Pliocene and Pleistocene Mollusks from the Santee-Cooper Area, South Carolina. Acad. Nat. Sci. Phila. Notula Naturae 118.

.... 1953 Record of the Rocks. Ronald Press, New York (413 pages).

Veatch, Otto and Stephenson, L. W. 1911 Preliminary Report on the Geology of the Coastal Plain of Georgia. Georgia Geol. Surv. Bull. 26.

The Pliocene Of Georgia*

by

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Relatively little is known about the Pliocene history of Georgia. Apparently only a small part of the Coastal Plain of the State was covered by the sea at any time during this epoch, and during much of it the State was probably entirely emerged.

EARLY PLIOCENE

During early Pliocene time the sea covered a considerable part of Florida. (See Fig. 1) During this stage the deposits of the Caloosahatchee formation were laid down. This formation is exceedingly rich in fossil mollusks, more than 500 species having been recorded, especially from the vicinity of Lake Okechobee.

This same early Pliocene sea probably also covered the margins of the present coastal plain of Georgia, extending as bays and estuaries up the present rivers. Unfortunately, most of the evidence for this ancient sea has been obscured by erosion or covered by sediments of Pleistocene age.

Only at a few places along the St. Marys and Satilla Rivers can we find outcrops of sediment left by this early Pliocene sea. This formation is called the Charlton, named from Charlton County, Georgia.

St. Mary's River. Twelve sections showing the Charlton formation have been described by Veatch and Stephenson

*This is the second article upon the geological history of the Georgia Coastal Plain, discussing its formation from youngest to oldest. In the last number of the News Letter Dr. Richards discussed the Pleistocene.

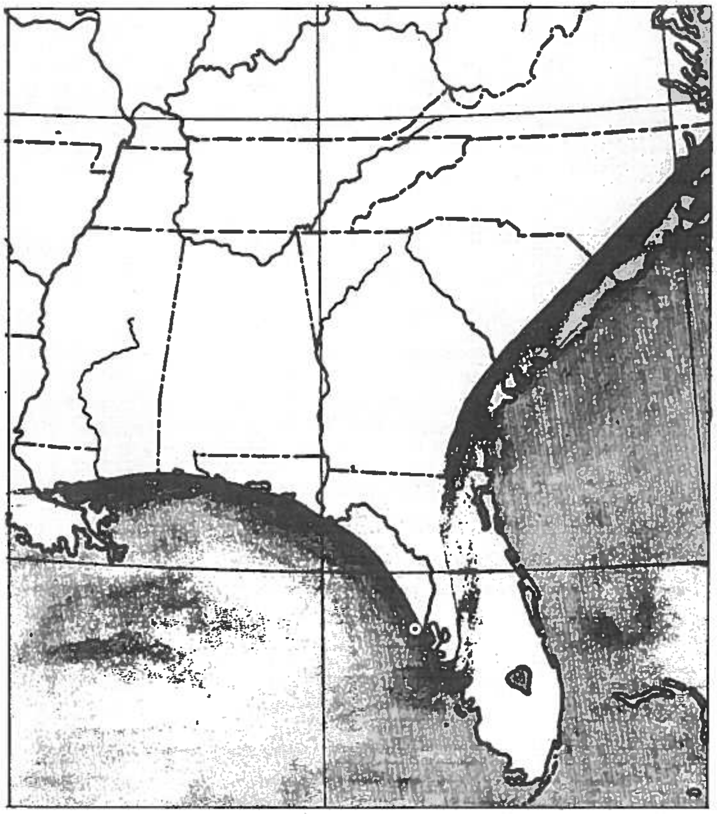


Fig. 1

Fig. 3

(1911) from the Florida side of the St. Mary's River between Stokes Ferry and Orange Bluff, opposite Charlton County, Georgia. In all cases the bluffs are low, never more than 20 feet, and it is probably that the formation is never more than about 20 feet in thickness.

Cooke (1936) summarized the data of Veatch and Stephenson, but added little new information on the Charlton formation.

The Charlton formation consists chiefly of light colored calcareous clay and some impure limestone. The few fossil mollusks that have been found in the Charlton formation are mostly species now living. In many cases the outcrops are below normal water level and fossils can be found only at times of low water. Figure 3 shows a typical Charlton locality at Orange Bluff, 2.5 miles above Kings Ferry, Florida. Here 4½ feet of clayey limestone exposed a few fossils, notably *Leda acuta, Pecten gibbus, Chione cancellata.* All of these were figured in earlier chapters of this series. Another species found at various places along the St. Mary's River in the Charlton formation is *Rangia cuneata* (fig. 4), a species more characteristic of the Pleistocene than the Pliocene.

Satilla River. Several outcrops of fossiliferous marl have been reported along the Satilla River by Veatch and Stephenson (1911) and Cooke (1936); for example 6 miles east of Winokur and 10.5 miles northeast of Folkston, but these localities have not been observed recently.

Aldrich (1911) reported some fossils from the bank of the Satilla River 4 miles south of Atkinson, Brantley County, Georgia. Here a lump of marl contained the following mollusks:

(Pelecypoda)
Rangia cuneata, Gray (Fig. 5)
Mulinia lateralis, Say (Part 2, Fig.)[1]
Mulinia congesta, Conrad (Fig. 6, 7)
Dosinia, sp.
Modiolaria sp.
Gemma purpurea, Lea
(Gastropoda)
Neritina sp.
Neverita sp.
Potamides saltillensis, Aldrich[2] (Fig. 8)
Potamides cancelloides, Aldrich (Fig. 9)
Amnicola Saltillensis, Aldrich (Figs. 12, 13)
Amnicola georgiensis, Aldrich, (Fig. 11)
Amnicola expansilabris, Aldrich, (Figs. 14, 15)
Planorbis antiquatus, Aldrich, (Figs. 16, 17)
Paludestrina plana, Aldrich (Fig. 10)

M. lateralis and *G. purpurea* live along the Georgia coast today. *R cuneata* is known from the Pleistocene of the Atlantic coast, but lives today only along the coast of the Gulf of Mexico. *M. congesta* is a Miocene and Pliocene species, while the last seven species of the list are freshwater forms described as new from this locality, and not known elsewhere.

This locality is difficult to find. When the writer visited it in 1936, good fossils could only be obtained from below water level. (See fig. 4).

[1] Part 1—Georgia Mineral News Letter Vol. 7 No. 2 pp. 70-76 (1954)
Part 2—Georgia Mineral News Letter Vol. 7, No. 3 pp. (1954)

[2] It will be noted that Aldrich misspelled the Satilla River as the "Saltilla" and named his new species accordingly.

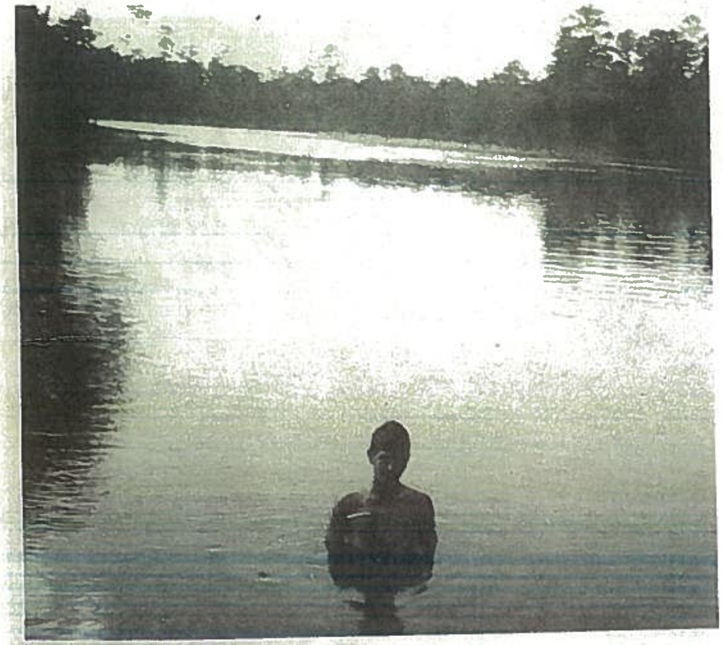


Fig. 4

It must be admitted that the age of the Charlton formation is still somewhat in doubt. Veatch and Stephenson and Cooke refer it to the Pliocene, equivalent to a phase of the Calosahatchee. However, the high percentage of recent forms along the St. Marys River suggests the possibility that it might be of early Pleistocene age. In some places, for example near Orange Bluff, the Charlton formation is overlaid by fossiliferous sands of the Pamlico formation (late Pleistocene.)

LATE PLIOCENE

During late Pliocene time the seas retreated far beyond

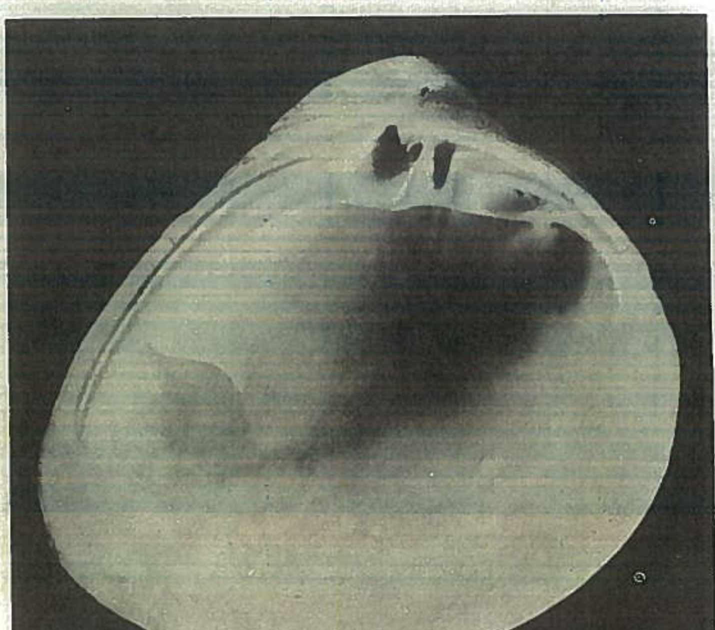


Fig. 5

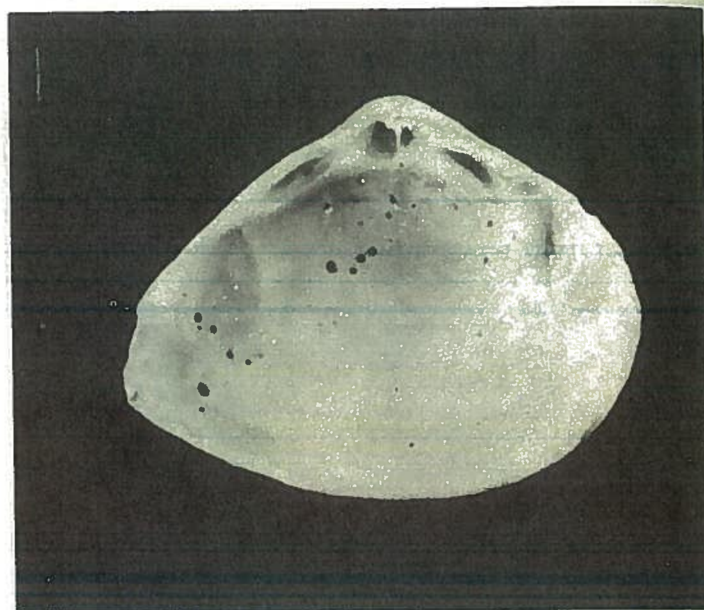


Fig. 6

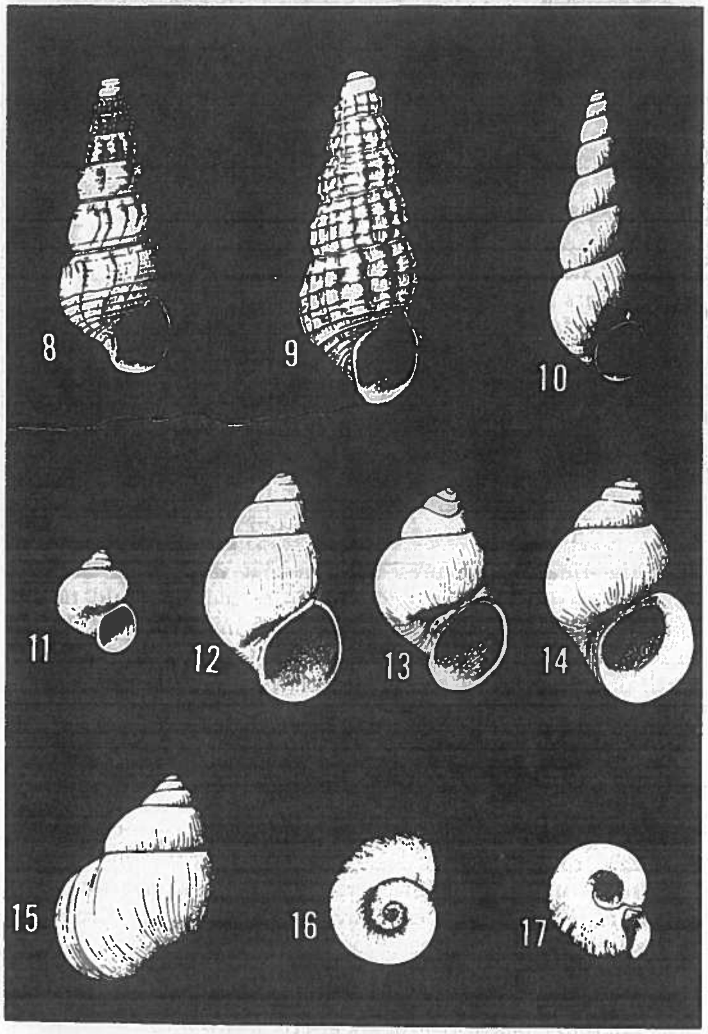
the present shore line with the result that no marine deposits of late Pliocene age are known from Georgia, or from anywhere else along the Atlantic Coast. (Fig. 18).

It is possible that the Appalachian Mountains were re-uplifted during this stage. At any rate, extensive deposits of sand and gravel were spread out over parts of the northern Coastal Plain, being carried by rivers flowing from the Appalachian Mountains eastward toward the Atlantic Ocean. (Richards, 1953, chapter 24)

Sand and gravel deposits, probably of late Pliocene age occur from New Jersey to the Carolinas and have been called the Beacon Hill, Bryn Mawr and "Lafayette" formations. (The latter name has recently been discarded.)

Veatch and Stephenson (1911) mapped the Altamaha formation (originally described in 1884) as a widespread mantle of sand and gravel covering three fifths of the Coastal Plain of Georgia. They regarded the age as highly uncertain, although they stated that part of it might be of Pliocene age, equivalent to the "Lafayette" formation elsewhere.

Fig. 7



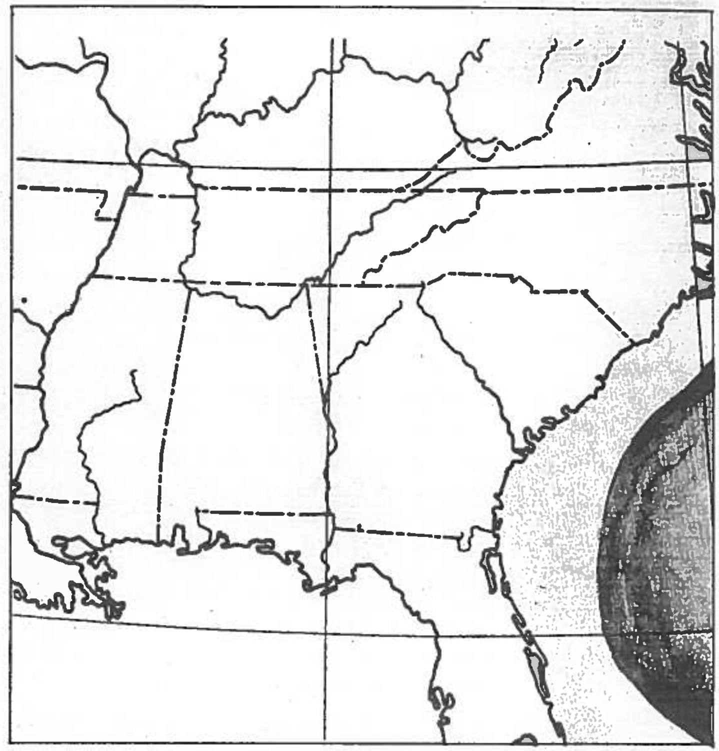


Fig. 18

Later workers have shown that much of the surficial mantle is actually of Pleistocene age, while other parts may be of Miocene or Oligocene age. Therefore, the presence of late Pliocene deposits in Georgia has not been positively demonstrated.

MacNeil (1950) mentions a high terrace in Georgia, western Florida, Alabama, and Mississippi, which occur at elevations from 250 to 280 feet. This terrace is believed to be of subaereal origin and may date from the early Pleistocene or the late Pliocene.

In his map MacNeil, (1947) shows older terraced surfaces as "fluvial or marine sand 8 to 10 feet thick, forming a broad, gently sloping, now greatly dissected, terraced surface." These are shown in Evans, Tattnall, Appling, Jeff Davis, Bacon, Ware, Pierce, Atkinson, Lanier, Lowndes, Clinch, Echols Counties as well as in a few isolated patches elsewhere. These deposits are regarded as Pliocene or Pleistocene.

REFERENCES

Aldrich, T. H. 1911 Notes on Some Pliocene Fossils from Georgia, with Descriptions of New Species. Nautilus, vol. 24, pp. 131-32; 138-40.

Cooke, C. Wythe 1936 Geology of the Coastal Plain of Georgia. U.S. Geol. Surv. Bull. 941.

MacNeil, F. Stearns 1947 Geologic Map of the Tertiary and Quaternary Formations of Georgia. U.S. Geol. Surv. Oil and Gas Investigations Prelim. Map 72.

.... 1950 Pleistocene Shore Lines in Florida and Georgia. U.S. Geol. Surv. Prof. Paper 221-F.

Richards, Horace G. 1953 Record of the Rocks. Ronald Press, New York (413 pages).

Veatch, Otto and Stephenson, L. W. 1911 Preliminary Report on the Geology of the Coastal Plain of Georgia. Georgia Geol. Surv. Bull. 26.

ILLUSTRATIONS

The Miocene Of Georgia*

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EARLY MIOCENE

Geological History. The generally accepted classification of the Miocene for Georgia is as follows:

Upper—Duplin
Middle—Hawthorn
Lower—Tampa

The Early Miocene submergence of the Atlantic Coastal Plain was not very extensive, the hypothetical shore line being shown on the accompanyihg map. Only two formations of early Miocene age are known from the Atlantic Coastal Plain: The Tampa limestone of Florida which extends into southwestern Georgia and which possibly underlies other portions of the State, and the Trent marl of extreme eastern North Carolina. It is probable that the rest of the Coastal Plain was above water during early Miocene time.

Tampa limestone. This formation, named for Tampa, Florida, is best developed in west-central Florida. It is well exposed along the Appalachicola River near River Junction and Chattahoochee, Florida and extends northeastward as a narrow band into Decatur, Grady, Mitchell and Worth counties, Georgia, to the vicinity of Sylvester. (See Geological Map). Near Chattahoochee, the Tampa is mainly a limestone. In southwestern Georgia it is either a limestone or a sand; in the northeastern part of its distribution, the Tampa formation is recognized merely by its characteristic chert. Part of the sandy phase of the Tampa formation was formerly called the "Chattahoochee formation" by Veatch and Stephenson (1911), but this term includes some sediments later assigned to the Flint River formation of Oligocene age (Cooke, 1943, p. 87).

Outcrops

1. **Chattahoochee, Gasden County, Fla.** The Tampa limestone is well exposed along Route 90 just east of the bridge over the Appalachicola River. Foraminifera, mollusks and some vertebrate fossils (probably sirenian ribs) have been collected at this locality. (Mansfield, 1937; Cooke, 1945).

2. **Near Faceville, Decatur County, Ga.** The Tampa limestone underlies the Hawthorn (middle Miocene) in various cuts along Highway 97 between Faceville and the Florida line. Micro-fossils have been obtained at this locality, but no mollusks or other large fossils have been reported.

3. **Wylie Landing, Flint River, Decatur County, Ga.** This locality is reported in the literature as 3 miles above the mouth of Spring Creek and 3½ miles north of the Florida line. Large oysters and other obscure mollusks have been reported from this locality. Because of the abandonment of river traffic and the many changes in roads and property lines, it was impossible to find this locality during the survey of 1954.

4. **Forest Falls Sink, Grady County, Ga.** At this sink hole 6.5 miles north of Whigham, a cream-colored Tampa limestone occurs on top of the Flint River (Oligocene) and beneath the Hawthorn (middle Miocene). The following section is abbreviated from Veatch and Stephenson (1911):

50 feet	Mostly sand and clay	MIOCENE	Hawthorn
30 "	Calcareous clay and limestone	MIOCENE	Tampa
35 "	Hard limestone; forams.	OLIGOCENE	Flint River

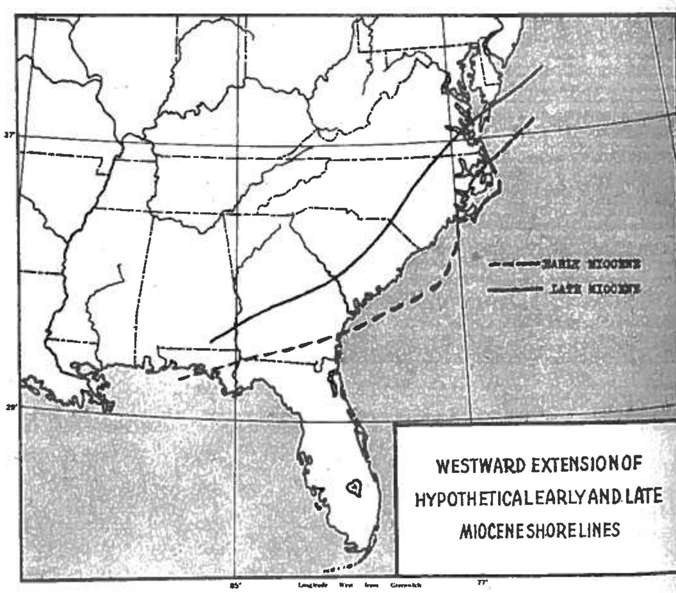
At the time of the present survey, it was noted that the sink was partly filled in and the entire section could not be measured. (To reach this sink drive 0.5 miles west of Climax on Route 84; then 2.1 miles north and 0.5 miles east. Sink is north of road behind a tenant house.)

A few other occurrences of Tampa limestone have been reported in the narrow band extending northeastward to the vicinity of Sylvester.

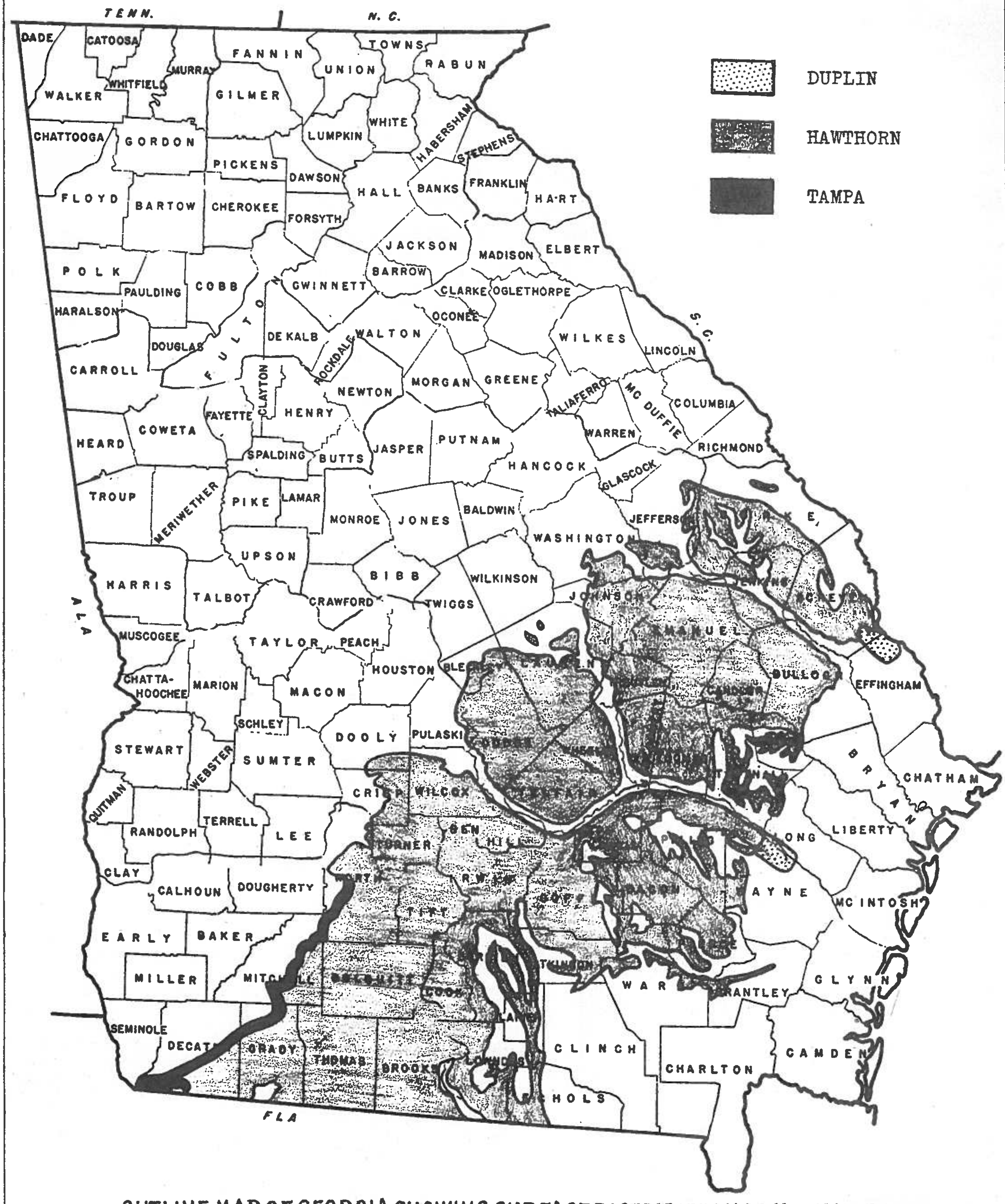
Fossils.

Fossils from the Tampa limestone of Georgia are limited to obscure mollusks. However, at Chattahoochee and elsewhere in Florida, an extensive fauna has been reported (Mansfield, 1937; Cooke, 1945). Among the species reported from Chattahoochee by Mansfield are the following mollusks:

Scaphander ballistus Mansfield
Potamides campanulatus Heilprin
Turritella pagodaeformis Heilprin
Arca umbonata Lamarck
Chlamys crocus Cooke (*Pecten*)
Modiolus blandus Dall
Antigona shephardi Dall
Lithophaga bisulcata d'Orbigny



*This is the second article upon the geological history of the Georgia Coastal Plain, discussing its formation from youngest to oldest. In the last number of the News Letter Dr. Richards discussed the Pliocene.



OUTLINE MAP OF GEORGIA SHOWING SURFACE DISTRIBUTION OF MIOCENE ROCKS

Hawthorn formation overlying Tampa limestone near Faceville, Decatur County, Georgia

The echinoid *Lovenia clarki* and some ribs, probably a sirenian, have also been found at this locality.

Mammals.

While all the deposits of the Tampa formation in Georgia are of marine origin, several localities in Florida indicate that part of that state must have been above the sea during Tampa time. Fossils from several localities in Florida include camels, deer, three-toed horses, rhinoceros, dogs, weasels, as well as land birds and water fowl. The best known locality for these early Miocene vertebrates is the Raeford Thomas farm (now owned by the University of Florida) in Gilchrist County, 8 miles north of Bell. (See Simpson, 1932).

MIDDLE MIOCENE

Geological History.—Although it is impossible to draw an accurate map of the Middle Miocene shore line of Georgia, it is assumed that more of the State was submerged than had been the case during Early Miocene time. Deposits of the Hawthorn formation were laid down during this stage.

Hawthorn formation. This formation is named from Hawthorn, Allachua County, Florida. According to Cooke (1943) it underlies "an enormous area that stretches from near Arcadia, Fla. to the vicinity of Charleston, S. C. In Georgia it lies near the surface throughout the Tifton Upland (wiregrass region) as well as the more fertile fields of Brooks and Thomas Counties."

The lithology of the Hawthorn varies greatly. In Florida and South Carolina it consists largely of phosphatic limestone, but this phase is less conspicuous in Georgia. In southern Georgia the Hawthorn consists of dolomitic limestone with conspicuous lenses of Fullers Earth. These lenses are especially numerous near Attapulgus, Decatur County and in Grady and Thomas Counties, Georgia, as well as in various localities in northern Florida. A sand and gravel phase —once called the "Altamaha grit"—also occurs widely in Georgia. In many places the soil produced by the Hawthorn formation shows a peculiar mottling of red and gray, the red color being the more conspicuous in the upper part of the section.

Outcrops.

The Hawthorn occurs widely in Georgia. Because of the lack of fossils only a few localities will be listed here. For general distribution see geologic map. (adapted from Cooke's geological map of 1943).

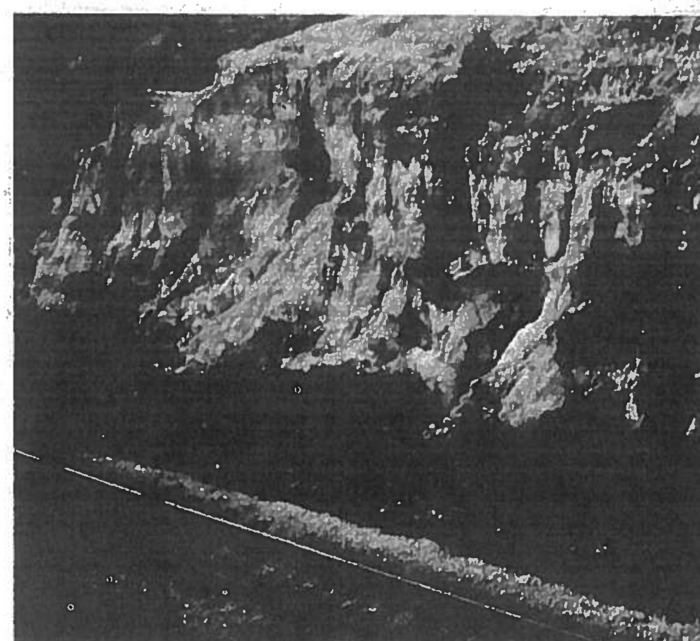
1. **Forest Falls Sink, Grady County, Ga.** As mentioned above, the Hawthorn overlies the Tampa in this sinkhole. A few indistinct fossils have been observed.

2. **Near Valdosta, Lowndes County, Ga.** Numerous good exposures of Hawthorn can be seen along Route 41 both north and south of Valdosta.

3. **Attapulgus, Decatur County, Ga.** Pits of the Minerals and Chemical Corporation of America (formerly Attapulgus Clay Company) are located in this area. The company produces a type of Fullers Earth of high quality known as "Attapulgite." Because of its minutely porous crystalline structure, one pound of Attapulgite contains 13 acres of active-surface area. Attapulgite materials are completely inorganic, chemically inert and free from toxicity. Attapulgite is processed for various purposes including petroleum refining adsorbents, floor cleaning adsorbents, agriculture insecticide carriers and drilling and mud additives.

4. **Cairo, Grady County, Ga.** Similar Fullers Earth is mined by the Cairo Production Company at Cairo.

5. **Porters Landing, Savannah River, Effingham County, Ga.** Exposures of the Hawthorn formation can be seen along the Savannah River in bluffs from "a point about a mile above Hudson's Ferry, Screven County, to Ebenezer Landing, Effingham County." (Cooke, 1943, p. 98). At Porters Landing where the Hawthorn underlies the Duplin marl a few poor specimens of **Ostrea normalis** and **Pecten akanikos**



Railroad cut showing Hawthorn formation at Climax, Decatur County, Georgia

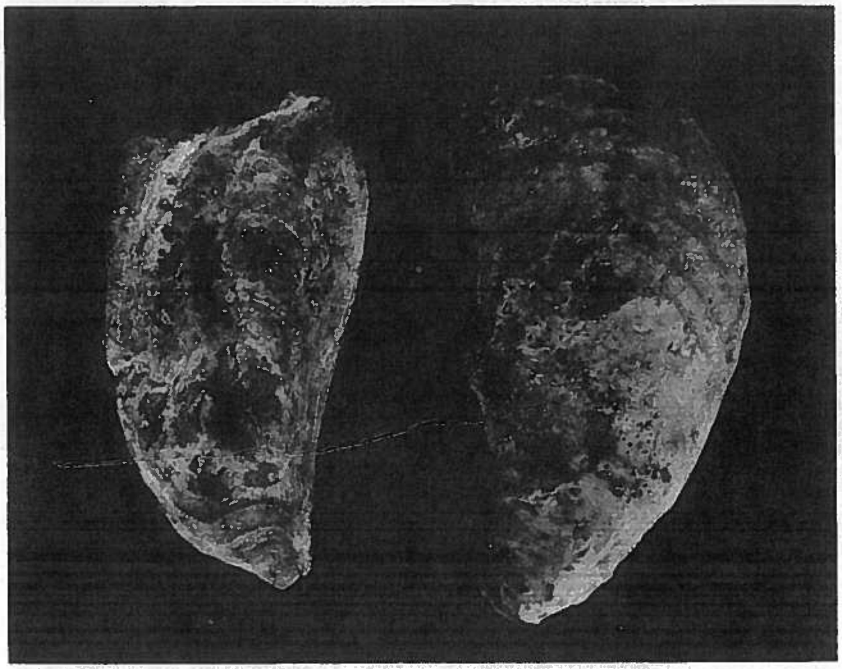


Figure 1

Figure 2

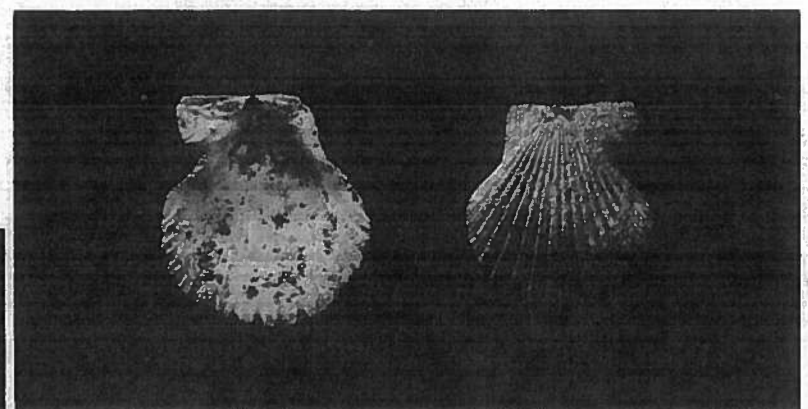
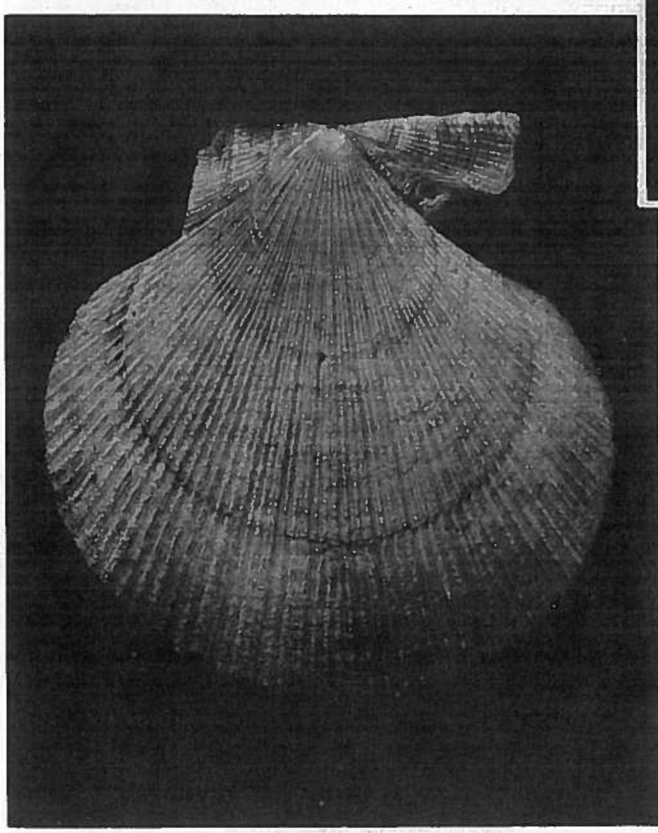


Figure 3

Figure 4



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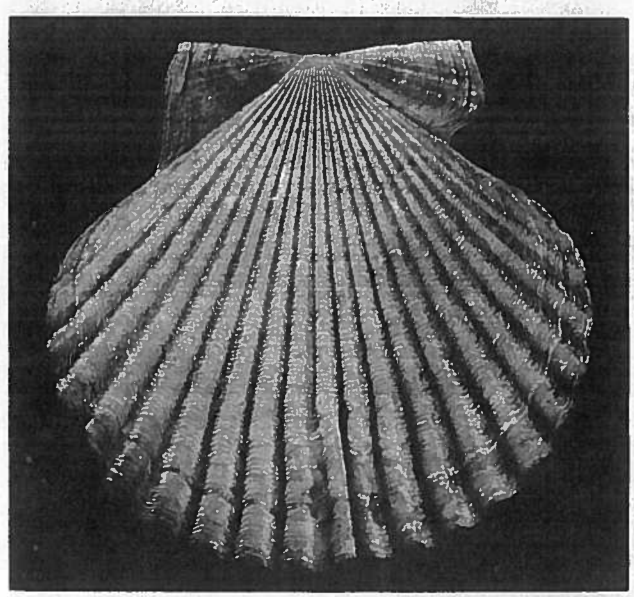

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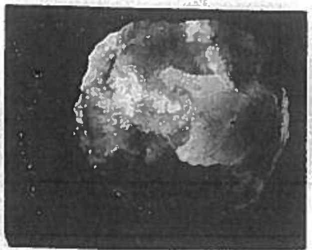

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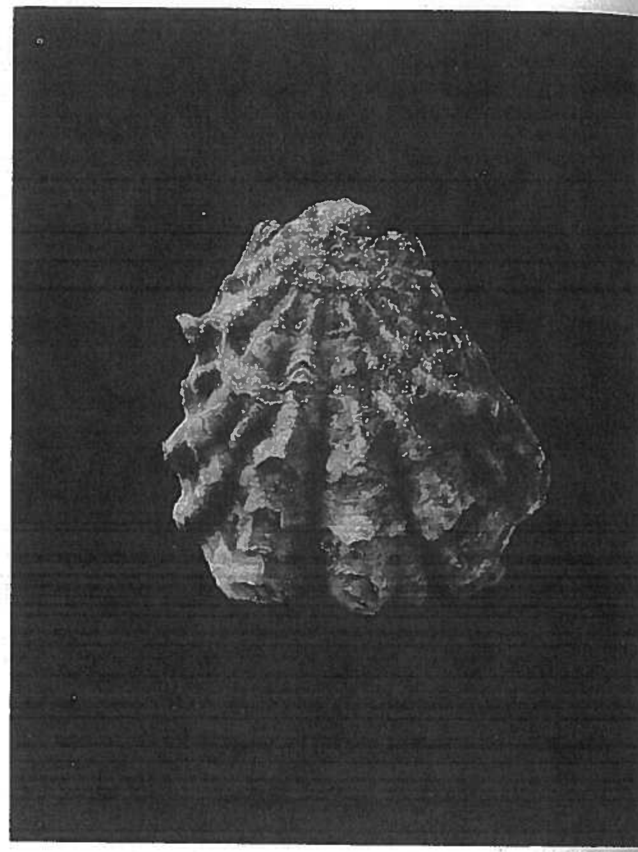

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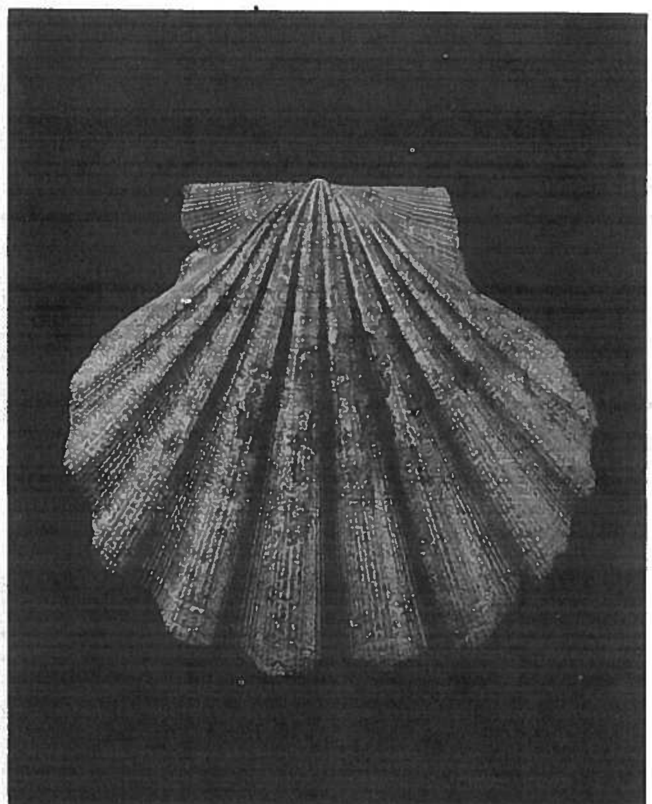

Figure 10

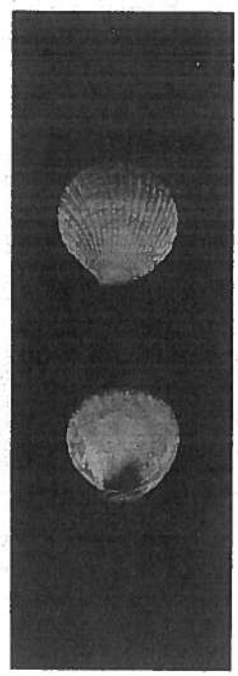

Figure 11

Figure 12

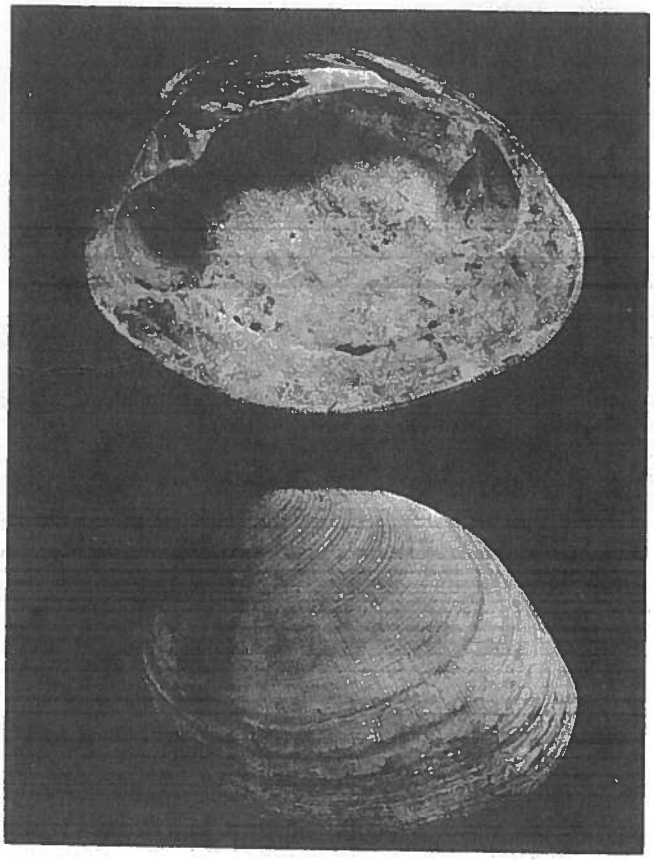

Figure 13

Figure 14

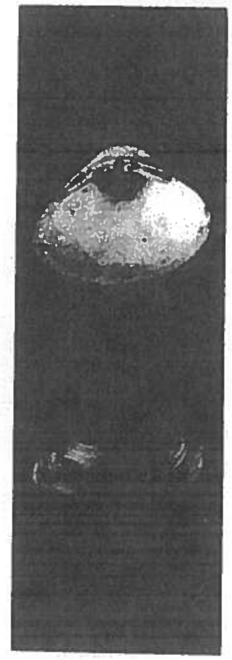

Figure 15

Figure 16

have been collected. Round concretions containing radial calcite crystals occur in the Hawthorn formation at this locality. (For further information on Porters Landing, see under Duplin marl.)

Fossils.

Although Gardner (1925) lists numerous fossils of the "Marks Head marl" (= Hawthorn formation) from the vicinity of Porters Landing, only fragments were obtained during the collecting trip of 1954. Among the mollusks reported by Gardner are the following:

GASTROPODA

Turritella sp.
Natica sp.
Calliostoma sp.

PELECYPODA

Scapharca staminata Dall ?
Ostrea normalis Dall Figs. 1, 2
Pecten acanikos Gardner Figs. 3, 4.
Carolia floridana Dall
Mytilus conradinus d'Orbigny
Astarte sp.
Venericardia sp.
Phacoides trisulcatus Conrad ?
Cardium sp.
Dosinia cf. *D. chipolana* Dall
Macrocallista sp.
Pecten marylandica Wagner Fig. 5

LATE MIOCENE

Geological History. The submergence of the Coastal Plain was more extensive during late Miocene time than it had been during the early or middle part of this epoch. The probable position of the late Miocene shore line is shown on the map adapted from Richards, 1953.

Duplin Marl. This formation, named from Duplin County, North Carolina, occurs in Georgia only locally along the Savannah and Altamaha Rivers. It consists of a sandy marl with many shell fragments. It is probably contemporaneous with the Yorktown formation of Virginia.

Outcrops.

1. **Porters Landing, Savannah River, Effingham County, Ga.** Here the Duplin marl is about 6 feet thick and overlies the Hawthorn formation. The shells are generally broken and consist mainly of

Pecten eboreus Conrad Fig. 6
Anomia simplex d'Orbigny Fig. 7
Earlier collections have been more extensive and include the following: (after Veatch and Stephenson, 1911 p. 368)

GASTROPODA

Turritella variabilis Conrad Fig. 8

PELECYPODA

Nucula proxima Say
Leda acuta Conrad
Ostrea sculpturara Conrad Fig. 9
Pecten eboreus Conrad Fig. 6
Pecten jeffersonius Say Fig. 10

Anomia simplex d'Orbigny Fig. 7
Venericardia granulata Say Figs. 11, 12
V. tridentata Say
Phacoides anodonta Say
P. radians Conrad
Venus tridachnoides Lamarck Figs. 13, 14
Mulinia congesta Conrad Figs. 15, 16
Corbula inaequalis Conrad

(Drive 3.5 miles northeast from Kildare to Mizpah Church; take road between church and school (Clyo Road) east for about 2 miles; take narrow dirt road to the left and proceed about 2 miles to the Savannah River.)

2. **Doctortown, Wayne County, Ga.** The Duplin marl here occurs at about water level on the west side of the Altamaha River. The best shells can be obtained near the base of the concrete surface water observation shelter. The following species have been identified:
Pecten eboreus Conrad Fig. 6
Mulinia congesta Conrad Figs. 15, 16
Ostrea sculpturata Conrad Fig. 9

Fossils.

Although relatively few species have been collected from the Duplin formation in Georgia, a very extensive fauna is known from the same formation in North and South Carolina, especially from Natural Well, Duplin County, N. C.

(Note: Since the fossils collected during the 1954 field trip were fragmentary, and since no Duplin material from Georgia is now available, the specimens photographed for this article have come from more distant localities.)

SELECTED BIBLIOGRAPHY

Cooke, C. Wythe — 1931 Radial Calcite Concretions in Marine Beds in Georgia. Jour. Wash. Acad. Sci. Vol. 21, p. 27.

.... — 1943 Geology of the Coastal Plain of Georgia. U. S. Geol. Surv. Bull. 941.

.... — 1945 Geology of Florida. Florida Geol. Surv. Bull. 29.

Gardner, Julia — 1925 The Detection of the Chipola Fauna in the Marks Head Marl. Jour. Wash. Acad. Sci. Vol. 15, pp. 264-268.

Mansfield, W. C. — 1937 Mollusks of the Tampa and Suwannee Limestones of Florida. Florida Geol. Surv. Bull. 15.

Richards, Horace G. — 1953 Record of the Rocks. Ronald Press, New York. (413 pages).

Simpson, George G. — 1932 Miocene Land Mammals from Florida. Florida Geol. Survey. Bull. 10.

Veatch, Otto and Stephenson, L. W. — 1911 Preliminary Report on the Geology of the Coastal Plain of Georgia. Georgia Geol. Surv. Bull. 26.

The Oligocene of Georgia

by

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Oligocene deposits are best developed in Mississippi where they have been given the name the Vicksburg group. Two formations—the Flint River and the Suwannee—have been described in Georgia, but is it probable that they represent a single submergence. In any case, it is obvious that portions of Georgia were covered by the sea during parts of Oligocene time. See accompanying map. (modified from Cooke, 1945)

Cooke (1943) stated that the Suwannee formation is of late Oligocene age, equivalent to the Chickasawhay marl of Mississippi, and that it grades up dip into a formation of sand, clay, limestone and chert to which the name Flint River was given. A separate formation name seemed justified because of the distinctive faunas, even though the Flint River deposits are mainly residual.

MacNeil (1947) expressed the view that the Oligocene is represented in Georgia by a single formation—the Suwannee—which "comprises an upper zone containing a Chickasawhay fauna, a middle zone containing a Glendon-Byram fauna, and a basal sand, probably a representative of the Mint Springs marl member of the Marianna limestone."

MacNeil (1947) stated that the equivalent of the lowermost Oligocene (Red Bluff clay) is absent in Georgia. However, in 1952, on the basis of a study of fossils from South Carolina, Cooke and MacNeil transferred the Cooper marl from the late Eocene to the early Oligocene equivalent to the Red Bluff of Alabama and Mississippi.

The accompanying map combines the outcrops of the Suwannee and Flint River, while those of the Cooper marl are shown by a different symbol.

Flint River formation. This formation was named by Cooke (1935) for deposits that are exposed in Georgia and Alabama above the Ocala limestone (Eocene) especially along the Flint River between Hales Landing and Red Bluff near Bainbridge, Georgia. These outcrops had previously been regarded as the lower part of the "Chattahoochee formation" by Veatch and Stephenson (1911). Further notes on the Flint River formation were given by Cooke in 1923 and 1935. In the latter paper a correlation is suggested with the Chickasawhay marl of Mississippi and the Antigua formation of the British West Indies. As mentioned above, Cooke (1943) regards the Flint River as the up dip equivalent of the Suwannee, while MacNeil (1947) has discontinued the use of the name Flint River entirely.

The Flint River formation probably originally varied from limestone to sand and gravel. Most of the limestone has been dissolved away leaving a residual clay, sand and gravel or silicified chert.

The formation extends across Georgia from the Chattahoochee River between Fort Gaines and the mouth of the Flint River to Screven County. (Cooke, 1943, p. 78). See accompanying map.

Suwannee Limestone. The term Suwannee limestone was first used by Cooke and Mansfield in 1936 for deposits that had previously been referred to the Vicksburg group, the Hawthorn formation, or the Tampa limestone. The type locality is along the Suwannee River at Ellaville, Florida. The formation extends up the Withlacoochee River possibly as far as Ousley, Lowndes County, Georgia, and probably underlies a much larger area in the state. (Cooke, 1943, p. 84).

Cooper marl. This formation is named from the Cooper River in South Carolina and until very recently has been regarded as a late phase of the Ocala or Santee limestones of Jackson Eocene age. In Georgia it occurs as a soft marly limestone north of Millen, Jenkins County and locally in Bleckley, Pulaski and Houston counties. It is probably also present in the subsurface between these localities and the vicinity of Charleston, S. C. (Cooke, 1943, p. 74). As stated earlier, Cooke and MacNeil, on the basis of the index pelecypod **Chlamys cocoana** (Dall), as well as the cetaceans, foraminifera and other fossils in South Carolina, have transferred the Cooper marl to the basal Oligocene.

Outcrops.

1. **Near Bainbridge, Decatur County, Ga.** The Flint River

Outcrop of Flint River formation between Hawkinsville and Clinchfield, Ga.

formation has been reported at various places along Flint River above and below Bainbridge. In the past, numerous fossils have been collected at Wyley Landing, south of Bainbridge and 3 miles above the mouth of Spring Creek. Here the Flint River formation is overlaid by the Tampa limestone (basal Miocene). Similar fossiliferous outcrops have been reported at Hales Landing, 6¼ miles southwest of Bainbridge and at Red Bluff, 6 miles north of Bainbridge. Because of the fact that these landings are no longer in use, it was impossible to find these localities during the survey of 1954. Fossils have been described .by Dall (1916), Cooke (1923) and others.

2. **Forest Falls Sink, Grady County, Ga.** The Flint River formation occurs at the bottom of this sink hole, 6.5 miles north of Whigham, where it underlies the Tampa and Hawthorne formations (Miocene). A few foraminifera have been collected. For further description of this locality see article on the Miocene of Georgia (Ga. Mineral News Letter, Spring, 1955, p. 27).

3. **Near Oakfield, Worth County, Ga.** Large residual blocks of white chert occur on State Route 257 about 1.5 miles south of Oakfield. Among the species collected are the following:

Glycymeris cookei Dall
Pecten poulsoni Morton
Lima halensis Dall
Phacoides (Miltha) sp.
Spondylus filiaris Dall
Amauropsis ocelana Dall
Turritella sp.
Conus cookei Dall
Cerithium spp.

4. **Near Sylvania, Screven County, Ga.** Many years ago fossils were obtained from a quarry on the H. T. Reddick property south of Beaverdam Creek about 6 miles north-northeast of Sylvania. The locality was not visited during the present survey. The gastropod **Cerithium georgianum** Lyell and Sowerby and the echinoid **Clypeaster jonesii** (Forbes) were described from this locality. According to Cooke, this is the Flint River formation.

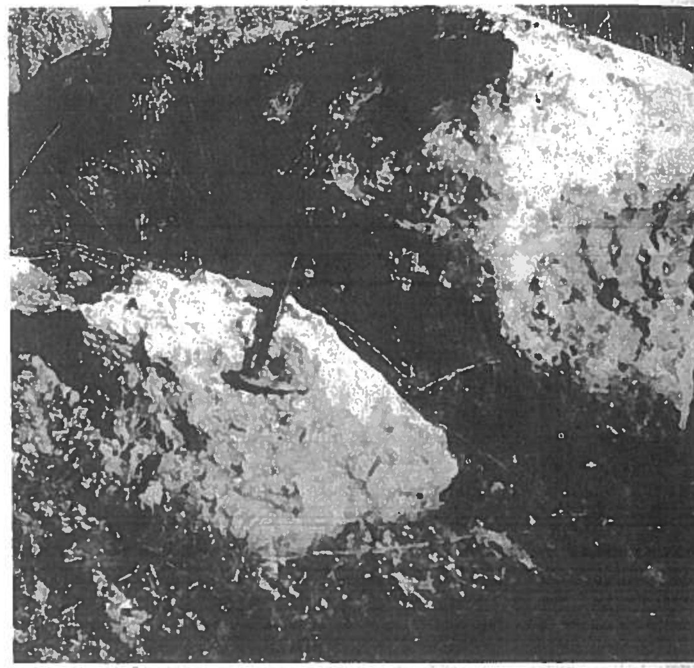
5. **South of Clinchfield, Houston County, Ga.** Residual boulders (Flint River) occur along Route 341 (between Hawkinsville and Clinchfield) both north and south of the Houston-Pulaski county line. Poorly preserved mollusks are present including the following:

Glycymeris cookei Dall
Lima halensis Dall
Pectem sp.
Crassatellites sp.
Phacoides sp.
Turritella sp.
Fusinus nexilus Dall

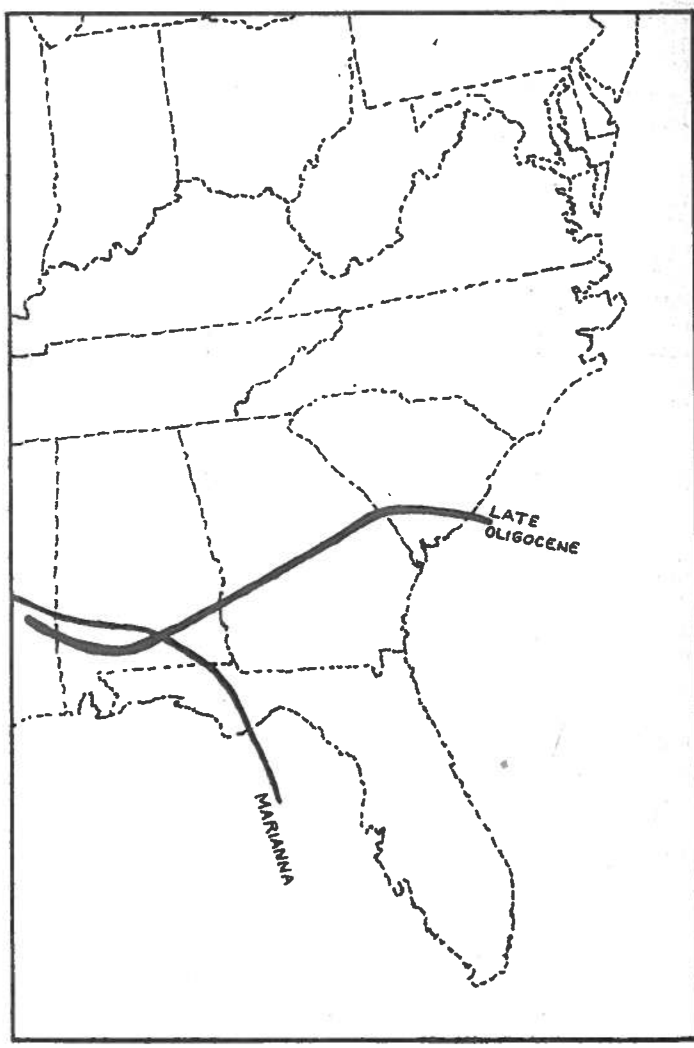
According to Guidebook 2 of the Southeastern Geological Society (1944), the Cooper marl underlies the Flint River formation at this locality. In this same guidebook, Stephen Herrick lists some 38 species of foraminifera from the Cooper marl at this locality (p. 49).

6. **Near Plains, Sumter County, Ga.** MacNeil, in the above mentioned guidebook records residual chert of the Flint River formation along Route 280 between Plains and the Webster County line. Upper Oligocene microfossils have been found.

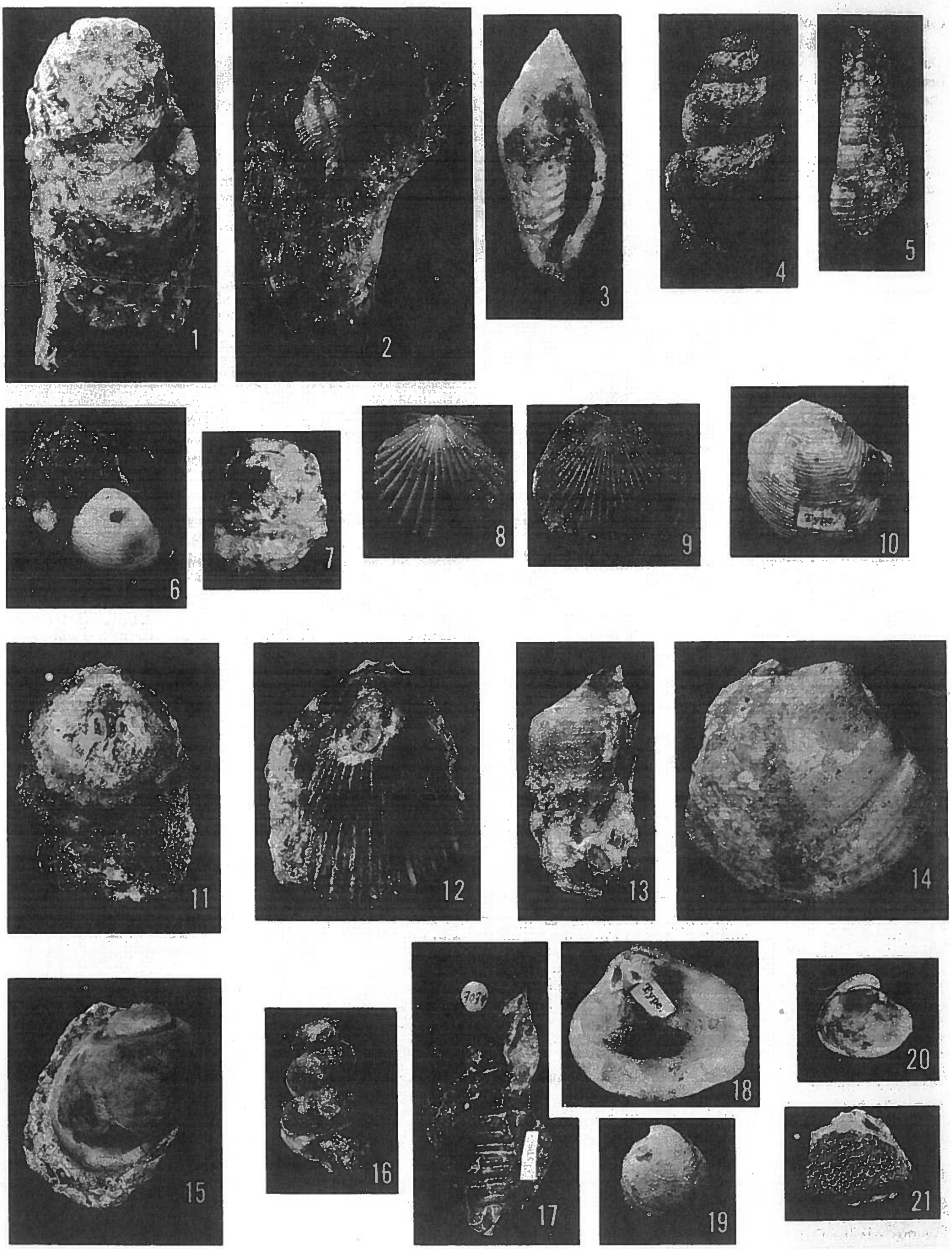
7. **Near Millen, Jenkins County, Ga.** Numerous sink holes occur near Millen and it is thought that these occur in the Cooper marl. Some years ago a collection of foraminifera was obtained from Spring Mill branch, 4.5 miles north of Millen. Various species typical of the Cooper marl of South Carolina were reported (Cooke, 1943, p. 75).



Residual chert of Flint River formation, 1.5 miles south of Oakfield, Georgia.



OLIGOCENE SHORELINES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Oligocene Fossils of Georgia

For complete list of Flint River mollusks of Georgia see Dall (1916) and Cooke (1923). Some of the corals have been described by Vaughan (1919, p. 199). The mollusks of the Suwannee limestone of Florida have been described by Mansfield (1937) in a report which also includes numerous records from Georgia. A report on the mollusks of the Chickasawhay marl of Mississippi, including numerous records from the Flint River area of Georgia, has also been published by Mansfield (1940).

The following table lists some of the characteristic Oligocene fossils from Georgia:

TYPICAL OLIGOCENE FOSSILS FROM GEORGIA

	Near Bainbridge	South of Oakfield	North of Hawkinsville	
Various corals	x			Fig. 21
PELECYPODA				
Pecten suwannenis Dall	x		x	Fig. 9
Pecten poulsoni Morton		x		Fig. 8
Lima halensis Dall	x	x	x	Fig. 12
Glycymeris cookei Dall	x	x	x	Fig. 11
Ostrea mauricensis Gabb	x			Fig. 1
Phacoides wacissanus Dall?	x	x		Fig. 19
Phacoides hillsboroensis (Heilprin)	x			Fig. 14
Phacoides (Miltha) sp.	x	x		
Crassatellites paramesus Dall	x	?		Figs. 10, 18
Spondylus filiaris Dall	x	x		
Pitaria silicifluvia Dall	x			Fig. 20
Chione bainbridgensis Dall	x	x		
Cytherea sobrina Conrad			x	Fig. 6
GASTROPODA				
Conus cookei Dall	x	x		
Conus vaughani Dall	x			Fig. 13
Cerithium cookei Dall	x	x		Fig. 5
Cerithium spp.	x	x	x	
Ampulina streptostoma (Heilprin)?	x			Fig. 15
Lyria mansfieldi Dall	x			Fig. 3
Turritella halensis Dall	x			Fig. 17
Turritella spp.	x	x		Fig. 16
Xenophora conchyliophora (Born)	x			Fig. 7
Amauropsis ocalana Dall	x	x		Fig. 4
Fusinus nexilus Dall			x	Fig. 2

SELECTED BIBLIOGRAPHY

Cooke, C. Wythe
1923. The Correlation of the Vicksburg Group. U.S. Geol. Surv. Prof. Paper 133, pp. 1-9.

———— 1936. Notes on the Vicksburg Group. Bull. Amer. Assoc. Petrol. Geol. Vol. 19, pp. 1162-72.

———— 1943. Geology of the Coastal Plain of Georgia. U.S. Geol. Surv. Bull. 941.
1945. Geology of Florida. Florida Geol. Surv. Bull. 29.

Cooke, C. Wythe, Gardner, Julia and Woodring, W. P.
1943. Correlation of the Cenozoic Formations of the Atlantic and Gulf Coastal Plain and the Caribbean Region. Bull. Geol. Soc. Amer. Vol. 54, pp. 1713-23.

Cooke, C. Wythe and Munyan, A. C.
1938. Stratigraphy of Coastal Plain of Georgia. Bull. Amer. Assoc. Petrol. Geol. Vol. 22, pp. 789-93.

Cooke, C. Wythe and MacNeil, F. S.
1952. Tertiary Stratigraphy of South Carolina. U.S. Geol. Surv. Prof. Paper 243-B.

Dall, W. H.
1916. A Contribution to the Invertebrate Fauna of the Oligocene Beds of Flint River, Georgia. Proc. U.S. Nat. Mus. Vol. 51, pp. 487-524.

Mansfield, W. C.
1937. Mollusks of the Tampa and Suwanee Limestones of Florida. Florida Geol. Surv. Bull. 15.

———— 1940. Mollusks of the Chickasawhay Marl. Jour. Paleont. Vol. 14, pp. 171-226.

MacNeil, F. S.
1947. Correlation Chart for the Outcropping Tertiary Formations of the Eastern Gulf Region. U.S. Geol. Surv. Oil and Gas Invest. Prelim. Chart 29.

Southeastern Geological Society
1944. Second Field Trip. Southwestern Georgia (includes notes on Oligocene of Georgia by F. Stearns MacNeil and Stephen M. Herrick.)

Vaughan, T. Wayland
1919. Fossil Corals from Central America, Cuba and Porto Rico, with an Account of the American Tertiary, Pleistocene and Recent Coral Reefs. U.S. Nat. Mus. Bull. 103.

ILLUSTRATIONS

1. *Ostrea mauricensis* Gabb
2. *Fusus nexilus* Dall
3. *Lyria mansfieldi* Dall
4. *Amauropsis ocalana* Dall
5. *Cerithium cookei* Dall
6. *Cytherea sobrina* Conrad
7. *Xenophora conchyliophora* (Born)
8. *Pecten polusoni* Morton
9. *Pecten suwannensis* Dall
10. *Crassatellites paramesus* Dall
11. *Glycymeris cookei* Dall
12. *Lima halensis* Dall
13. *Conus vaughani* Dall
14. *Phacoides hillsboroensis* (Heilprin)
15. *Ampulina streptostoma* (Heilprin)
16. *Turritella* sp.
17. *Turritella halensis* Dall
18. *Crassiatellites paramesus* Dall
19. *Phacoides wacissanus* Dall?
20. *Pitaria siliciflùvia* Dall
21. Coral

(ALL NATURAL SIZE)

The Paleocene and Eocene of Georgia

(Part 2: Upper Eocene)

by

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BARNWELL FORMATION

The Barnwell sand was originally named by Sloan (1907) from Barnwell County, South Carolina. The formation name was extended into Georgia by Veatch and Stephenson (1911), but it together with the McBean were placed in the Claiborne group. Later work by Cooke and Shearer (1918) redefined the formation and demonstrated its Jackson (late Eocene) age. They also included in the Barnwell part of the material which Veatch and Stephenson had referred to the Jackson formation. The "Congaree clay member of the McBean formation" was redefined as the Twiggs clay member of the Barnwell formation. The Upper Eocene formations of Georgia were summarized by Cooke in 1943.

The Barnwell formation extends from the South Carolina-Georgia line almost to Flint River. (See map.) Typically, it is a fine to coarse argillaceous sand which weathers to a brilliant shade of red. Cooke (1943 p. 62) suggests that the color is due to the oxidation of the small grains of glauconite which are disseminated throughout the sand.

The Twiggs clay member, best developed in Twiggs County where it reaches a thickness of 100 feet, consists of greenish-grey brittle clay interbedded with layers of sand. It becomes calcareous toward the west and merges into the Ocala limestone. The Twiggs clay is locally used as Fullers Earth. The Sandersville limestone, locally exposed near Sandersville, Washington County, is light grey and chalky and is probably not more than 40 feet thick.

The Barnwell formation lies disconformably on the McBean but the contact is not always distinct, some localities being referred questionably to either formation. It is probably of the same age as the Ocala limestone with which it merges toward the southwest.

Localities

1. **Shell Bluff, Burke County, Ga.** Both Barnwell and McBean are represented in this famous bluff on the Savannah River. This locality was discussed in the previous number of this series (Vol. 8, No. 3, p. 113, Autumn, 1955).

2. **Louisville, Jefferson County, Ga.** Cooke and Shearer (1918) report a 57½ foot section of the Barnwell sand in a gully on the east slope of Rocky Comfort Creek about 300 yards above the highway bridge three-quarters of a mile west of Louisville.

3. **Old Town, Jefferson County, Ga.** A road cut on Route 17 8.4 miles southeast of Louisville at "Old Town" south of Mill Creek reveals a sandy chert with numerous fossils including the echinoid *Periarchus* and the following mollusks: *Turritella carinata* Lea, *Mesalia vetusta* (Conrad), *Calyptraea aperta* (Solander), *Glycymeris staminea* (Conrad), *G. idonea* (Conrad), *Crassatella* sp., *Venericardia alticostata* (Conrad), *Cytherea perovata* Conrad, *Corbula densata* Co[nrad].

4. **Sandersville, Washington County, Ga.** The type localit[y] of the Sandersville limestone is a sink and a spring west [of] the Tennile Road 0.8 miles south of the Courthouse at Sa[n]dersville. It was impossible to locate this during the fiel[d] work of 1954.

5. **Keg Creek, 6 miles northwest of Sandersville, Washing[ton] County, Ga.** As mentioned in the previous article ([p.] 113) it is uncertain whether this locality should be correlate[d] with the overlying Barnwell. Fossils are listed by Cooke (194[3], p. 55).

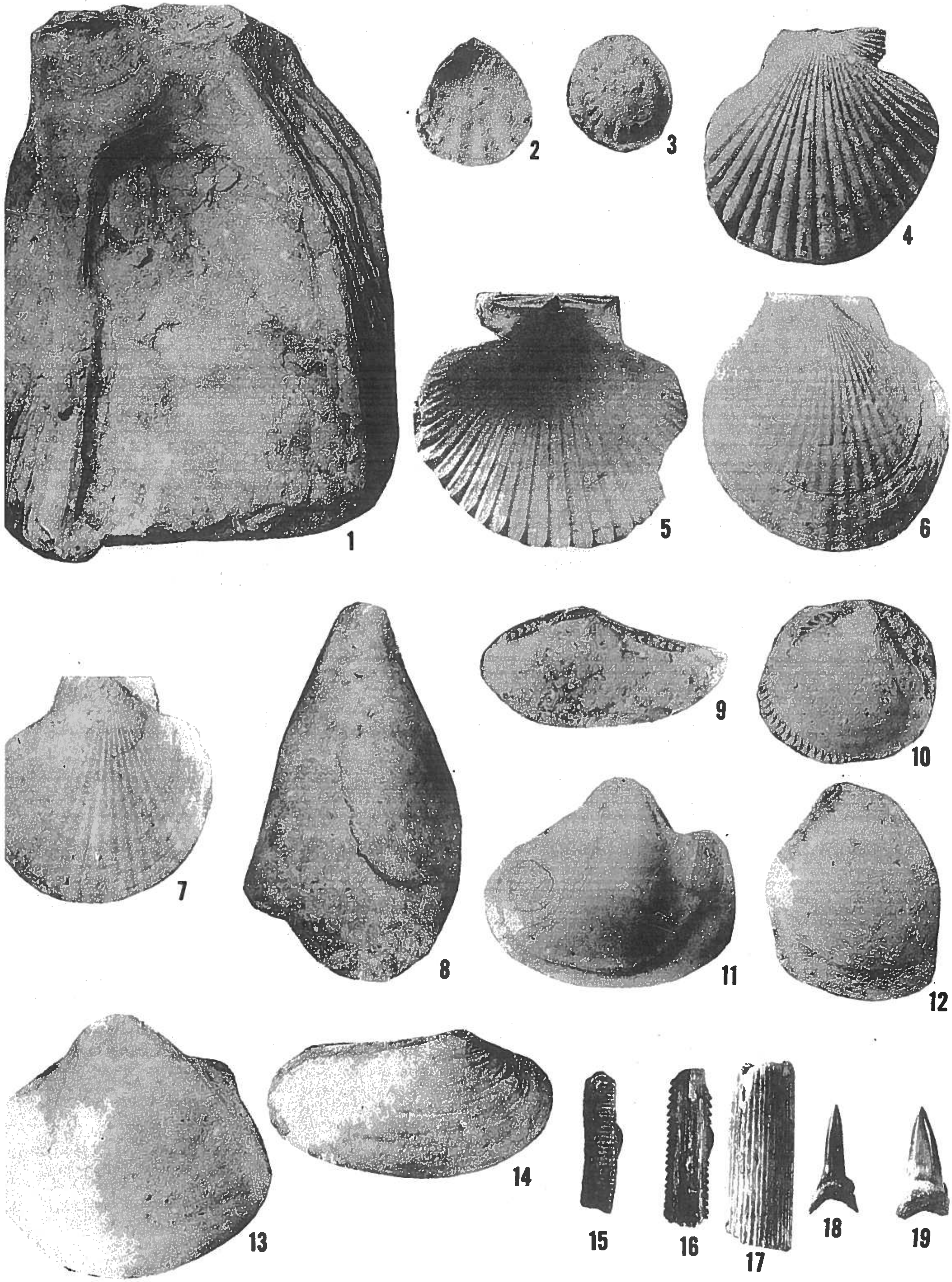
6. **Dry Branch, Twiggs County, Ga.** The Barnwell forma[tion] overlies the Tuscaloosa clay at the pits of the Georg[ia] Kaolin Company about 3 miles east of Dry Branch. Th[e] foraminfera are listed by Rainwater (1944, p. 42). Amo[ng] the macrofossils collected by the present survey in Decembe[r] 1954 are the following:

Pelecypoda	Gastropoda
Glycymeris spp.	*Calytraea* aperta (Solande[r])
Pecten perplanus Morton	*Turritella* sp.
Cardium sp.	(Coral)
Crassatella sp.	*Flabellum* sp.
Ostrea sp.	(Fish)
"Lucina" sp.	*Cylindrocanthus* (spine)
	Shark teeth
	plate of Ray

OCALA LIMESTONE

The Ocala limestone, named for the town of that na[me] in Marion County in Florida, is well developed in that sta[te] and extends northeastward into Georgia as far as Wilkins[on] County. (See map.) Most of the rocks in Georgia now kno[wn] to be the Ocala limestone were classified by Veatch a[nd] Stephenson (1911) as the Vicksburg formation with whi[ch] the Ocala limestone of Florida was then correlated. So[me] deposits, now regarded as Ocala, were referred to the Jac[k]son formation by Veatch and Stephenson. The Jackson (la[te] Eocene) age of the Ocala was pointed out by Cooke (191[5]) and has been reaffirmed in later writings (Cooke and Shear[er] 1918, Cooke, 1943).

The Ocala is chiefly a white or cream-colored pure lim[e]stone, although toward the base where it grades into t[he] Gosport it may be sandy. Unaltered parts of the Ocala a[re] soft and friable, there are also layers of hard rock in whi[ch]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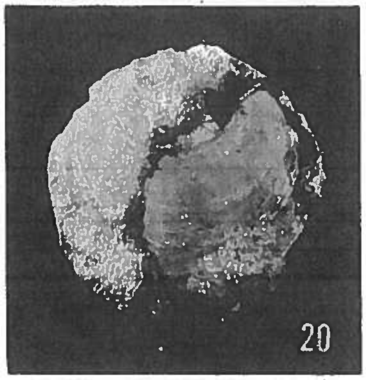
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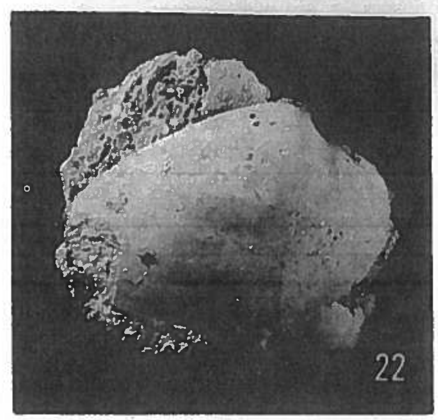
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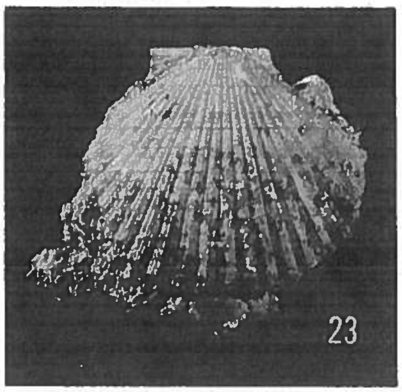
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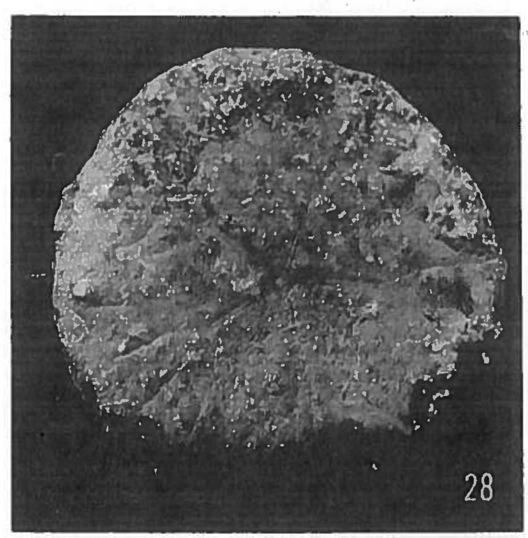
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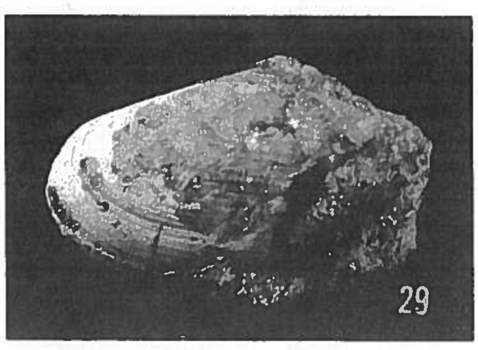
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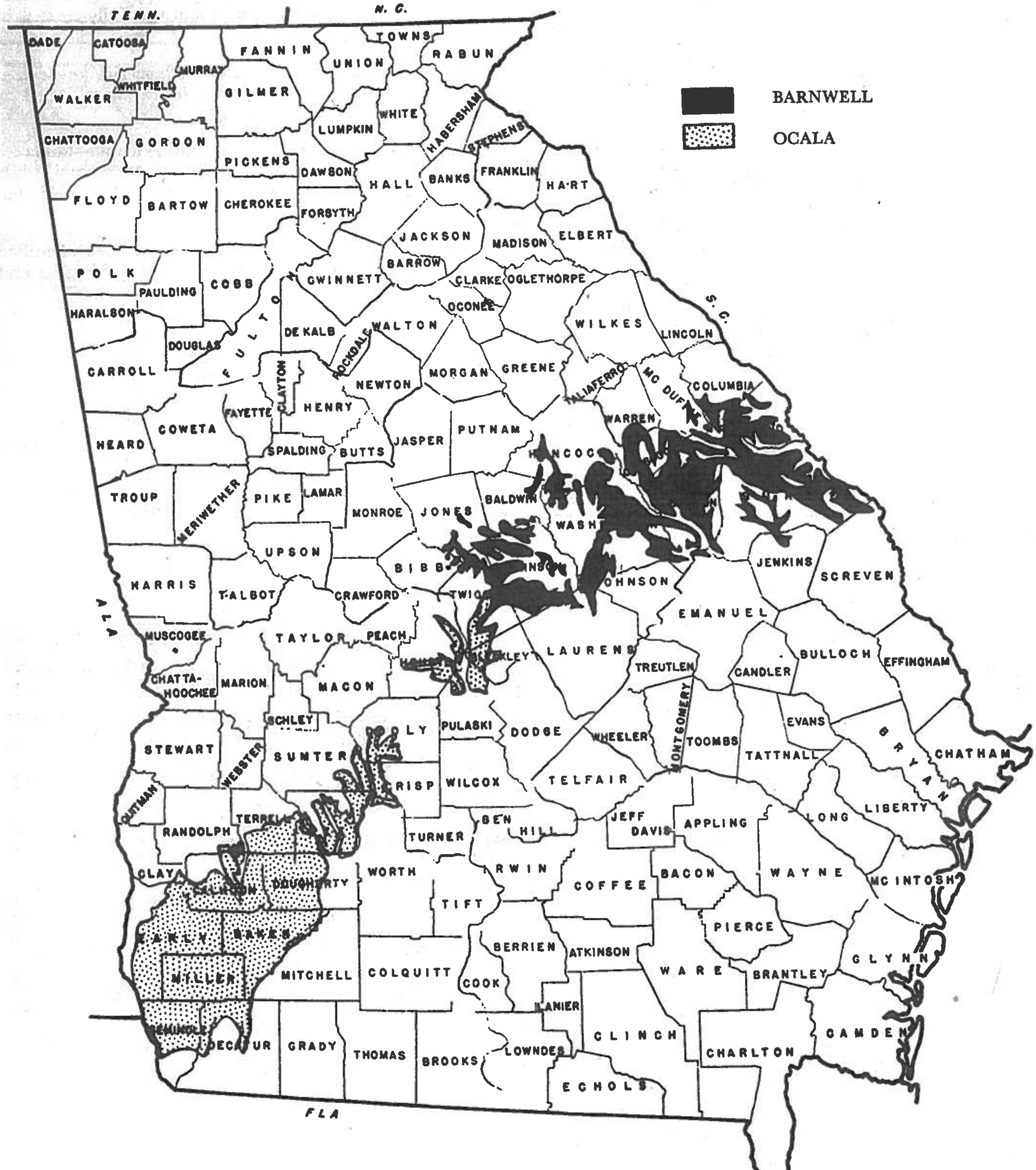
COUNTY OUTLINE MAP OF GEORGIA



Outcrops of Barnwell and Ocala formations in Georgia.

the pores have been filled by calcite. The thickness of the formation may be as much as 300 feet. It is an important aquifer of south Georgia. The correlations of the Ocala were discussed by MacNeil (1944, pp. 32-35).

Since the fauna of the Ocala formation of Florida and Georgia is now being studied by Dr. Katherine V. W. Palmer, of the Paleontological Research Institution of Ithaca, New York, the material collected during the 1954 survey has been sent to her for study. For this reason, only brief notes will be given at this time.

Localities

1. **Clinchfield, Houston County, Ga.** The extensive quarries of the Penn-Dixie Cement Corporation on the east side of Route 341 at Clinchfield expose a 75 foot section of Ocala limestone along with the overlying Twiggs clay. The Ocala foraminifera were listed by Rainwater while those of the overlying Twiggs clay and Cooper marl were recorded by Herrick in the Guidebook of the second field trip of the Southeastern Geological Society in 1944. (pp. 47-49)

The locality was visited by the writer in April and December 1954. While most of the fossils collected have been sent to Dr. Palmer for study in connection with her report on the Ocala fauna, the following can be listed at this time:

Ostrea georgiana Conrad
Chlamys spillmani (Gabb)
var, *clinchfieldensis* Harris
Atrina jacksoniana Dall
Crassatella ocordia Harris
C. sp.
Tellina sp.
Glycymeris cf. *anteparilis* Kellum
Pitar cf. *cornelli* Harris
P. cf. *subimpressa* Conrad
Cardium nicolletti Conrad
Panope oblongata (Conrad)
Arcoperna sp.
Macrocallista sp.
Glycymeris sp.

2. **Perry, Houston County, Ga.** Similar fossiliferous Ocala limestone is exposed in the pits of the Georgia Lime Rock Company 4 miles south of Perry.

3. **Armena, Lee County, Ga.** Numerous fossils were obtained from the Ocala limestone at the Armena Lime Mines on the "Old Cocke Farm," 10 miles west of Albany on Route 82.

4. **Albany, Dougherty County, Ga.** The Ocala limestone is exposed along Flint River just below the dam at the mouth of Kinchafoonee Creek. Fossils have been obtained from this locality by Harris (1951) and the present survey.

5. **Ainsley Station, Bleckley County, Ga.** Many fossils were obtained from the Ocala limestone in a quarry at Ainsley station about 12 miles northwest of Cochran. These fossils are being studied by Dr. Palmer.

6. **Rich Hill, 4.5 miles southeast of Knoxville, Crawford County, Ga.** Road cuts on Route 42 expose the Ocala limestone overlying Tuscaloosa clay. Foraminifera have been recorded by Rainwater. (1944 p. 45) ostracodes, bryozoa and mollusks may also be observed.

Fauna of the Ocala Formation

As stated previously in this article, a full report on the molluscan fauna of the Ocala of Georgia and Florida is being prepared by Dr. Katherine V. W. Palmer. For this reason, only brief notes will be given at this time. Some Ocala species were discussed and figured by Harris (1951) and the related Jackson fauna of the Gulf Coastal Plain was fully treated by Harris and Palmer (1946).

Cushman (1935) has listed some 32 species of smaller foraminifera while some of the larger forms are recorded by Cooke (1943, p. 69).

Canu and Bassler (1920) record an extensive fauna of Jacksonian bryozoa from North Carolina to Mississippi, while some echinoids have been listed by Cooke (1942, 1943, pp. 69-70).

Three species of Zeuglodont cetaceans have been identified by Kellogg (1936) from the Ocala formation in Houston and Crisp counties, Georgia.

References

Canu, Ferdinand and Bassler, R. S.
1920. North American Early Tertiary Bryozoa. U. S. Nat. Mus. Bull. 106.

Cooke, C. Wythe
1915. The Age of the Ocala Limestone. U. S. Geol. Surv. Prof. Paper 95.

———
1942. Cenozoic Irregular Echinoids of Eastern United States. Jour. Paleont. Vol. 16, pp. 1-62.

———
1943. Geology of the Coastal Plain of Georgia. U. S. Geol. Surv. Bull. 941.

Cooke, C. Wythe and Shearer, H. K.
1918. Deposits of Claiborne and Jackson Age in Georgia. U. S. Geol. Surv. Prof. Paper 120.

Cushman, J. A.
1935. Upper Eocene Foraminifera of the Southeastern United States. U. S. Geol. Surv. Prof. Paper 181.

Harris, G. D.
1951. Preliminary Notes on Ocala Bivalves. Bull. Amer. Paleont. Vol. 33, No. 138, pp. 1-54.

Harris, G. D. and Palmer, Katherine V. W.
1946. The Mollusca of the Jackson Eocene of the Mississippi Embayment (Sabine River to the Alabama River.) Bull. Amer. Paleont. Vol. 30, No. 117.

Herrick, Stephen
1944. *in* Guidebook for Second Field Trip of Southeastern Geological Society.

Kellogg, Remington
1936. A Review of the Archaeoceti. Washington.

MacNeil, F. Stearns
1944. The Tertiary Formations *in* Guidebook for Second Field Trip of Southeastern Geological Society.

Rainwater, E. H.
1944. *in* Guidebook for Second Field Trip of Southeastern Geological Society.

Sloan, Earl
1907. Catalogue of the Mineral Localities of South Carolina.

Veatch, Otto and Stephenson, L. W.
1911. Preliminary Report on the Geology of the Coastal Plain of Georgia. Georgia Geol. Surv. Bull. 26.

Illustrations

Map. Outcrops of Barnwell and Ocala formations in Georgia.
A. Ocala Limestone at Penn-Dixie Cement Corporation, Clinchfield, Ga.
B. Ocala Limestone at Georgia Lime Rock Company near Perry, Ga.

Fossils

1. *Ostrea georgiana* Conrad, Clinchfield, Ga. (slightly reduced)
2. *Plicatula filementosa* Conrad, Armenia, Ga. (x1½)
3. *Plicatula filementosa* Conrad, Kendrick, Fla. (x2)
4. *Chlamys spillmani* var. *clinchfieldensis* Harris, Clinchfield, Ga. (x1)
5. *Chlamys spillmani* var. *clinchfieldensis* Harris, Clinchfield, Ga. (x1)
6. *Amusium ocalanum* Dall, Kendrick, Fla. (x1¼)
7. *Amusium ocalanum* Dall, Kendrick, Fla. (x1¼)
8. *Atrina jacksoniana* Dall?, Clinchfield, Ga. (x1)
9. *Nuculana* sp., Perry, Ga. (x4)
10. *Glycymeris* cf. *anteparilis* Kellum, Clinchfield, Ga. (slightly enlarged)
11. *Crassatella,* sp., Clinchfield, Ga. (slightly reduced)
12. *Lucina perovata* Dall, Perry, Ga. (x1¼)
13. *Protocardia nicolletti* Conrad, Perry Ga. (slightly enlarged)
14. *Panopea oblongata* Conrad, Perry, Ga. (x1¼)
15. Dental plate of Ray, Dry Branch, Ga. (x1)
16. Spine of Fish, Dry Branch, Ga. (x1)
17. Spine of Fish (Cylindrocanthus sp.), Dry Branch, Ga. (x1)
18. Shark Tooth, Dry Branch, Ga. (x1)
19. Shark Tooth, Dry Branch, Ga. (x1)

Figures 1-14 after Harris (1951); courtesy Paleontological Research Institution.

20. *Amusium ocalanum* Dall, Perry, Ga. (x1)
21. *Glycymeris* sp., Clinchfield, Ga. (x1)
22. *Macrocallista* sp., Clinchfield, Ga. (x1)
23. *Chlamys* sp., Clinchfield, Ga. (x1)
24. *Turritella* sp., Dukes Bridge near Waynesboro Ga. (Barnwell formation) (x1)
25. *Turritella carinata* Lea, Old Town, Ga. (x1)
26. *Calyptraea aperta* (Solander), Dry Branch, Ga. (x1)
27. *Flabellum* sp. (coral), Dry Branch, Ga. (x1)
28. *Periarchus* sp., near Sandersville, Ga.
29. *Crassatella* sp., Dukes Bridge near Waynesboro, Ga. (Barnwell formation) (x1)
30. Foram., Clinchfield, Ga. (x1)

The Paleocene and Eocene of Georgia

(Part 1: Paleocene, Lower and Middle Eocene)

by

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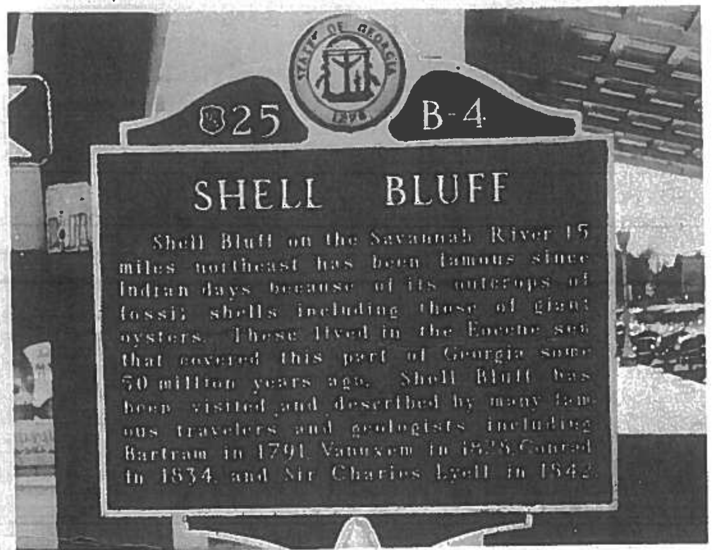
At least the greater part of the Coastal Plain of Georgia was covered by the sea several times during Paleocene and Eocene times. However, because of the lack of detailed paleogeographic studies, it is impossible to map the position of the different shorelines. The approximate extent of the outcrops of the various major formations is shown on the accompanying map.*

Prior to Cooke's report of 1943, the term Paleocene was not used for formations in Georgia, the deposits now being referred to it being classed as the lowermost Eocene. However, when comparisons were made with formations along the Gulf Coast and in the "western interior" of the United States, the subdivision of the Eocene into the Eocene proper and a still lower Paleocene seemed justified. The present classification of the major stratigraphic units of Georgia is as follows:

Age	Major formations	Gulf Coast equivalent
EOCENE or OLIGOCENE	Cooper marl	....
Upper EOCENE	Ocala; Barnwell; Santee	JACKSON
Middle EOCENE	McBean	CLAIBORNE
Lower EOCENE	Wilcox	WILCOX
PALEOCENE	Clayton	MIDWAY

*In addition to the acknowledgments cited in the first article of this series, the author wishes to express his thanks to Dr. David Nicol, of the United States National Museum, for lending specimens for study and photographing.



State Marker at Waynesboro, Georgia with directions to Shell Bluff.

Clayton Formation

The Clayton formation was named for Clayton, Alabama, only 18 miles west of Georgetown, Quitman County, Georgia. The formation extends northeastward into Georgia as far as Twiggs County, and probably occurs in the subsurface over a wider area in the State.

The Clayton formation "includes two beds—an upper bed composed of 15 feet of brittle calcareous light-gray clay, and a lower one with 35 feet of sandy white limestone containing *Ostrea crenulimarginata* and grading downward into coarse rusty-yellow sand and grading laterally into irregularly hardened calcareous sand. The bed rests unconformably on the Providence sand, of Upper Cretaceous age." (Cooke, 1943, pp. 40-41). The upper clay layer is probably equivalent to the Porters Creek clay of Alabama. Judging from well records, the Clayton attains a thickness of at least 400 feet.

Localities

1. **Fort Gaines, Clay County, Ga.** The Clayton limestone is exposed at various places on both sides of the Chattahoochee River from Fort Gaines to a point 7 miles above the town. On the Georgia side of the highway bridge at Fort Gaines, the Clayton consists of yellowish limestone containing echinoid spines and other obscure fossils. It here underlies the Wilcox formation. For a more detailed description of the Clayton in the vicinity of Fort Gaines, see Guidebook 2 issued by the Southeastern Geological Society (MacNeil, 1944, p. 22). See also section under locality 1 of the Wilcox formation of this report.

2. **Griers Cave, Randolph County, Ga.** Clayton limestone is well exposed in two quarries along Route 27, 9 miles north of Cuthbert. Griers Cave, which is in a field near one of these quarries and at the headwaters of Punkin Creek, also exposes a considerable thickness of Clayton limestone. The total thickness of the Clayton in this area is thought to be about 50 feet. Numerous molluscan casts were obtained from these quarries including the following: *Venericardia, Cardium, Ostrea, Panope, and Protocardia.* Others still remain to be identified.

3. **Near Preston, Webster County, Ga.** Veatch and Stephenson (1911) reported 15 feet of hard grayish limestone or marlstone at Lime Spring on the south side of Kinchafoonee Creek, two miles southeast of Preston. Various fossils including *Ostrea crenulimarginata, O. pulaskensis* ?, *Turritella humerosa* and *Mesalia alabamensis* were collected at this locality. It was not possible to visit this locality during the present investigation.

4. **Andersonville, Sumter County, Ga.** MacNeil (1944, p. 51) records some Midway foraminifera at a road cut on Route 49 about one mile south of Andersonville cemetery. A fault crosses the road at this point; core drilling for bauxite about a mile east of the highway showed it to have a 90 foot development. According to MacNeil, this outcrop is equivalent to the Naheola formation of Alabama.

Fossils

Herrick and Cole (1953) have recorded two species of larger foraminifera from the Porters Creek Clay (= upper Clayton) in several Georgia wells. In the same paper, Herrick lists some 17 species of associated smaller foraminifera.

No specific study has been made on the macrofossils of the Clayton formation of Georgia. However, many Clayton species have been discussed in the work on the Midway fauna of the Gulf Coast by Harris (1896).

Ostrea crenulimarginate from near mouth of Sandy Creek, Chattahoochee River, Georgia.

Among the mollusks characteristic of the Clayton formation of Georgia are the following:

Venericardia planicosta s.l.
V. smithi
Ostrea crenulimarginata
O. pulaskensis
Cytherea ripleyana
Protocardia sp.
Turritella humerosa
T. alabamensis
Mesalia alabamensis
Panope sp.
Cardium cf. *tuomeyi*
Cimona sp. *(Nautiloid)*

Wilcox Formation

The term Wilcox is used for a group of formations in Alabama—the Ackerman, Nanafalia, Salt Mountain, Tuscahoma, Bashi, and Hatchetibee (oldest to youngest). The name is derived from Wilcox County, Alabama. Cooke (1943) did

not attempt to subdivide the Wilcox of Georgia into its different constituents. However, later work on the bauxite deposits of the State by MacNeil (1947, a, b) and others has differentiated at least several of the Alabama subdivisions. These units are best recognized near Fort Gaines, Georgia, (MacNeil, 1944, pp. 23-28). However, in view of the general nature of the present series of articles, no attempt is being made to differentiate the various units of the Wilcox in this article.

The Wilcox formation of Georgia is exposed only in valleys and lowlands between Fort Gaines and Americus. On higher ground it is generally covered by the McBean and Flint River formations. In Georgia, the Wilcox generally consists of fine sand and gray laminated clay. Good exposures are relatively rare.

Localities

1. **Fort Gaines, Clay County, Ga.** The Wilcox formation overlies the Clayton on the Georgia side of the Chattahoochee River at the highway bridge at Fort Gaines. The following section is abbreviated from Cooke (1943, p. 49).

Sand and gravel	PLEISTOCENE	33 feet
Mostly sand, with some clay lenses; a few mollusk fragments	WILCOX	106 feet
Limestone with echinoid spines and obscure fossils	CLAYTON	13 feet

Among the fossils found in the Wilcox in this vicinity are *Ostrea sellaeformis, Pecten deshayesii* and *O. compressirostra.* The material collected on the 1954 field trip was rather poorly preserved. However, judging from material in the collections of the Academy of Natural Sciences, some excellent specimens must have been obtained in former years.

As stated above, MacNeil has subdivided the Wilcox into various units in the vicinity of Fort Gaines.

The Wilcox is exposed along the Chattahoochee River at various places above Fort Gaines, but it was not possible to visit them during the present survey. See Veatch and Stephenson (1911) and Cooke (1943).

2. **Troutman, Stewart County, Ga.** Cooke (1943, p. 52) reports "an unconformable contact of cross-bedded pebbly sand of the McBean formation and glauconitic sand of Wilcox age . . . 21 feet above water in Nochaway Creek, 1 mile north-northwest of Crittenden Mill and 3 miles north-northeast of Troutman." A similar exposure was reported from a spring west of the Georgia, Florida and Alabama Railroad, 1¼ miles north-northeast of Troutman. The fauna as reported by Cooke suggested a correlation with the Bashi member of the Wilcox in Alabama. These localities could not be found during the present survey.

3. **Cuthbert, Randolph County, Ga.** According to MacNeil (1944, p. 59) "fossiliferous lower Tuscahoma glauconitic sand occurs in a ditch at the foot of a hill along Route 50, 4.6 miles west of Cuthbert." It is overlaid by non-fossiliferous middle Tuscahoma shale and sand in the road cut higher up the hill. The glauconitic sand contains specimens of *Pecten greggi* and *Ostrea compressirostra.*

4. **Andersonville, Sumter County, Ga.** American Cyanamid Company and its predecessor, the Kalbfleisch Corporation have obtained bauxite from the Wilcox formation in the Andersonville area.

Fossils

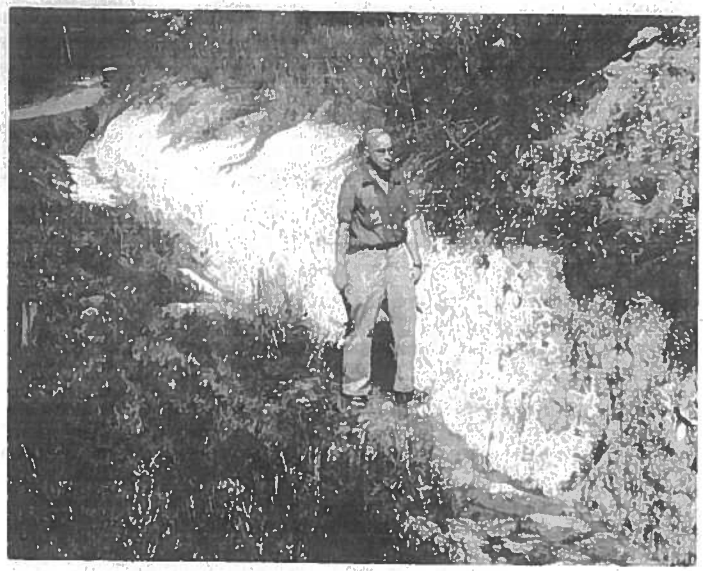
Among the mollusks reported from the Wilcox of Georgia are the following:

Venericardia alticostata
Ostrea sellaeformis
O. compressirostra
O. thirsae
Pecten deshayesii
P. greggi
Nucula ovula
Nuculana sp.
Cytherea sp.

For further details on the Wilcox fauna, see the works of Harris (1897, 1899) on the Lignitic Stage, which is approximately equivalent to the Wilcox of present terminology.

McBean formation

The Middle Eocene is represented in Georgia by the McBean formation, named for the town and creek of that name in Richmond County, Georgia. The formation was originally described by Veatch and Stephenson (1911), but was re-described and restricted by Cooke and Shearer (1918). It has been summarized by Cooke (1943) and was remapped by MacNeil (1947a). It may be equivalent to the Tallahatta and Lisbon formations of Alabama, or as shown in the chart of MacNeil (1947b), the type McBean may represent only the upper part of the Claiborne (Middle Eocene). The Gosport sand of Alabama is thought by some to be equivalent to the McBean, while others regard the Gosport as basal Jackson (Late Eocene). In any case, it is difficult to separate the Gosport from the McBean and they are mapped together by MacNeil (1947a).



McBean outcrop at Keg Creek, 6 miles northwest of Sandersville, Georgia.

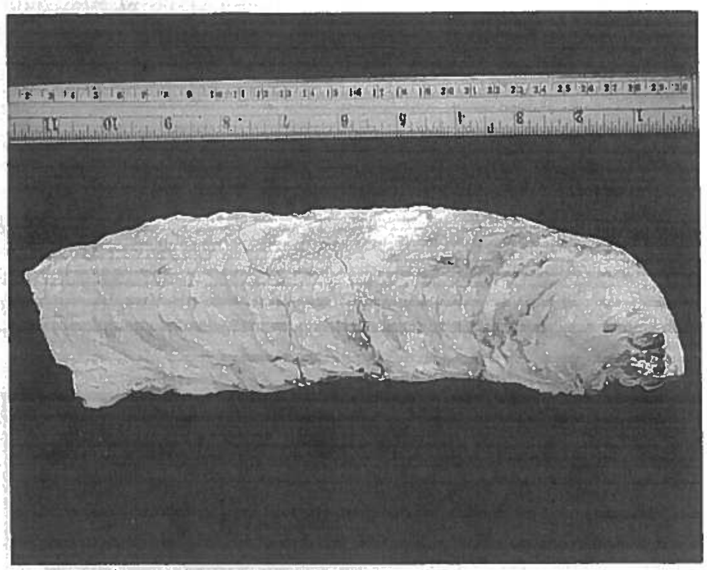
The McBean formation is typically a fine loose yellow sand with a few patches of sandstone and calcareous material. The sand merges downward into a marl with occasional patches of Fuller's Earth. As shown by wells, the thickness of the McBean rarely exceeds 100 feet.

The classic locality at Shell Bluff on the Savannah River has been well known to naturalists and geologists for more than 150 years.

Localities

1. **McBean, Richmond County, Ga.** A typical locality of the McBean formation is on the south side of McBean Creek about ¼ mile below McBean at the Richmond-Burke county line. Although no fossils were observed during the 1954 visit, specimens of *Ostrea sellaeformis* and the echinoid *Periarchus lyelli* have been found there in the past*

2. **Shell Bluff, Burke County, Ga.** This well known locality occurs on the west side of the Savannah River about 7 miles east of the small settlement of Shell Bluff. Veatch and Stephenson (1911) correlated the extensive shell bed with the McBean formation. On the other hand, Cooke and Shearer (1918) believed that only the lower part of the section should be correlated with the McBean, while the upper bed containing the many specimens of *Ostrea gigantissima*** should be correlated with the Barnwell. Therefore, the exact age of this famous shell bed which is made up almost entirely of *Ostrea gigantissima,* one of the largest of East American oysters, must be regarded as uncertain. See accompanying figures.



Ostrea gigantissima from Shell Bluff, Georgia.

3. **Keg Creek, 6 miles northwest of Sandersville, Washington County, Ga.** Here a road cut of State Highway 15 shows the white kaolin of the Tuscaloosa formation (Cretaceous) overlaid by a greenish gray clayey marl with various species of coral, bryozoa and mollusks. For complete lists of species, see Cooke, (1943, p. 55).

As in the case of the *O. gigantissima* bed at Shell Bluff, it is uncertain whether this fauna should be correlated with the McBean or the overlying Barnwell.

4. **Danville Bluff, Sumter County, Ga.** This locality occurs on the west side of Flint River about 1 mile above the mouth of Pennahatchie Creek. It can be reached by turning north from the Vienna-Americus road (State Route 27) west of the Flint River bridge and following dirt roads to the site of old Danville Bluff. An extensive microfauna has been recorded from this locality (Rainwater, 1944, p. 53).

5. **Near Fort Gaines, Clay County, Ga.** MacNeil (1944, p. 30) reports the presence of the McBean formation along the Chattahoochee River near Fort Gaines.

Fossils

Fossil plants of Claiborne age have been collected near Grovetown, Columbia County, and south of Macon, Bibb County. (Berry, 1914).

For a complete discussion of the Claiborne fauna of the Gulf Coastal Plain, including some Georgia species, see the papers of Harris (1919) and Palmer (1937). The Keg Creek fauna, which may be younger than Claiborne, has been listed by Cooke (1943, p. 55). Among the mollusks from the McBean of Georgia, the following may be regarded as characteristic:

Venericardia alticostata
Arca rhomboidella
Tellina raveneli?
Ostrea gigantissima
Glycymeris sp.
Pecten membranosus
Buccinops sp.
Conus sp.
Turritella sp.

Illustrations

Note: Since some of the fossils obtained from the Paleocene and Eocene deposits of Georgia were not suitable for photographing, in some cases representatives of the same species from Alabama or Mississippi have been figured in this article.

1,2. *Venericardia planicosta* Lamarck (sensu lato)
3. *Ostrea thirsae* Gabb
4. *Ostrea pulaskensis* Harris
5. *Ostrea sellaeformis* Conrad
6. *Ostrea compressirostra* Say
7. *Tellina raveneli* Conrad (?)
8. *Ostrea thirsae* Gabb
9. *Venericardia alticostata* Conrad
10. *Ostrea sellaeformis* Conrad
11. *Conus* sp.
12. *Pecten membranosus* Morton
13. *Pecten deshayesii* Lea
14. *Pecten greggi* Harris
15. *Cardium* cf. *tuomeyi* Aldrich
16. *Buccinopsis* sp.
17. *Turritella* sp.
18. *Arca rhomboidella* Lea
19. *Glycymeris* sp.
20. *Cytherea* sp.
(All natural size)

References

Berry, E. W.
1914. Upper Cretaceous and Eocene Floras of South Carolina and Georgia. U. S. Geol. Surv. Prof. Paper 84.

Cole, W. Stors and Herrick, Stephen M.
1953. Two Species of Larger Foraminifera from Paleocene Beds in Georgia. Bull. Amer. Paleont. Vol. 35 (No. 148), pp. 49-62.

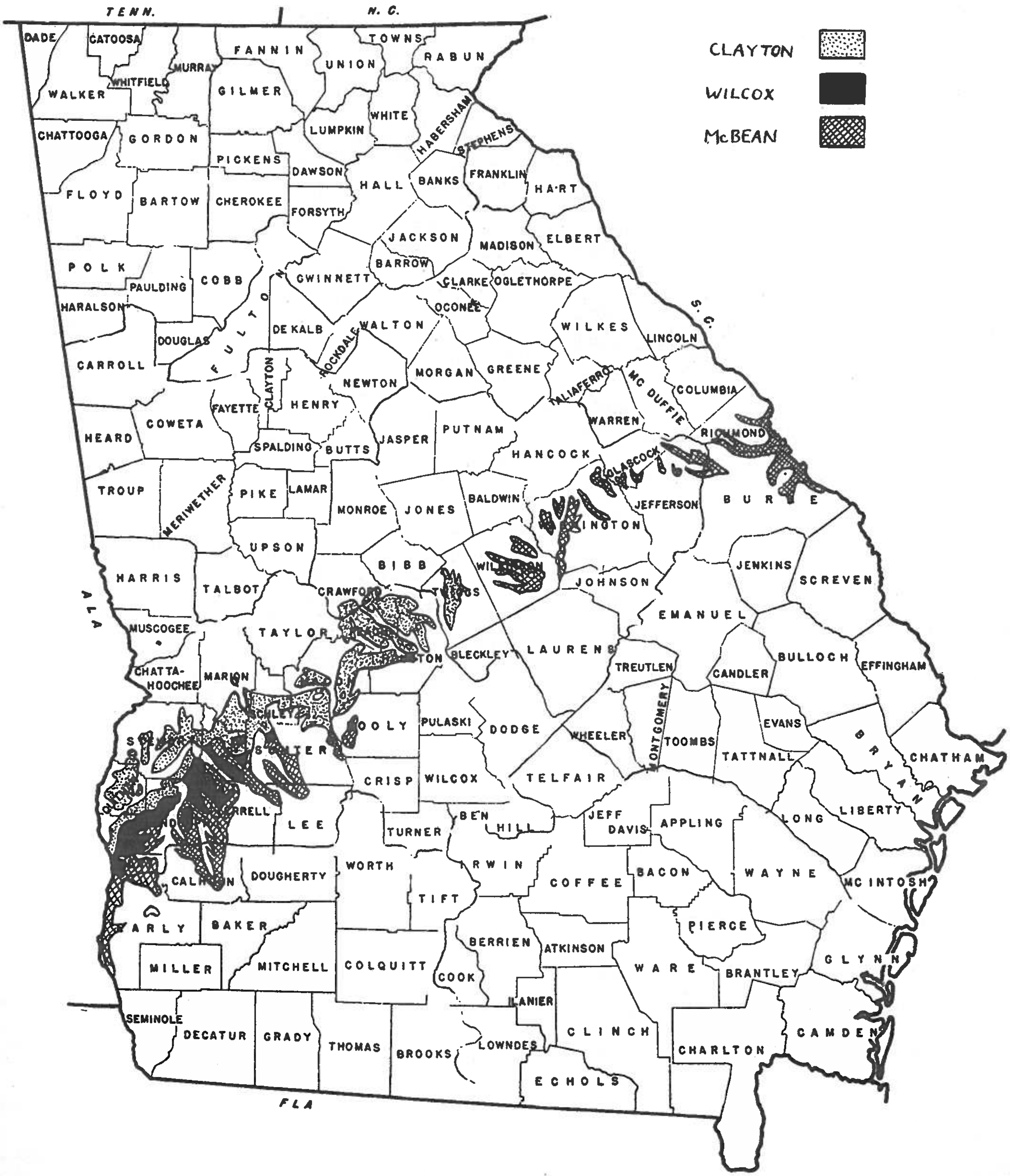
Cooke, C. Wythe
1943. Geology of the Coastal Plain of Georgia. U. S. Geol. Surv. Bull. 941.

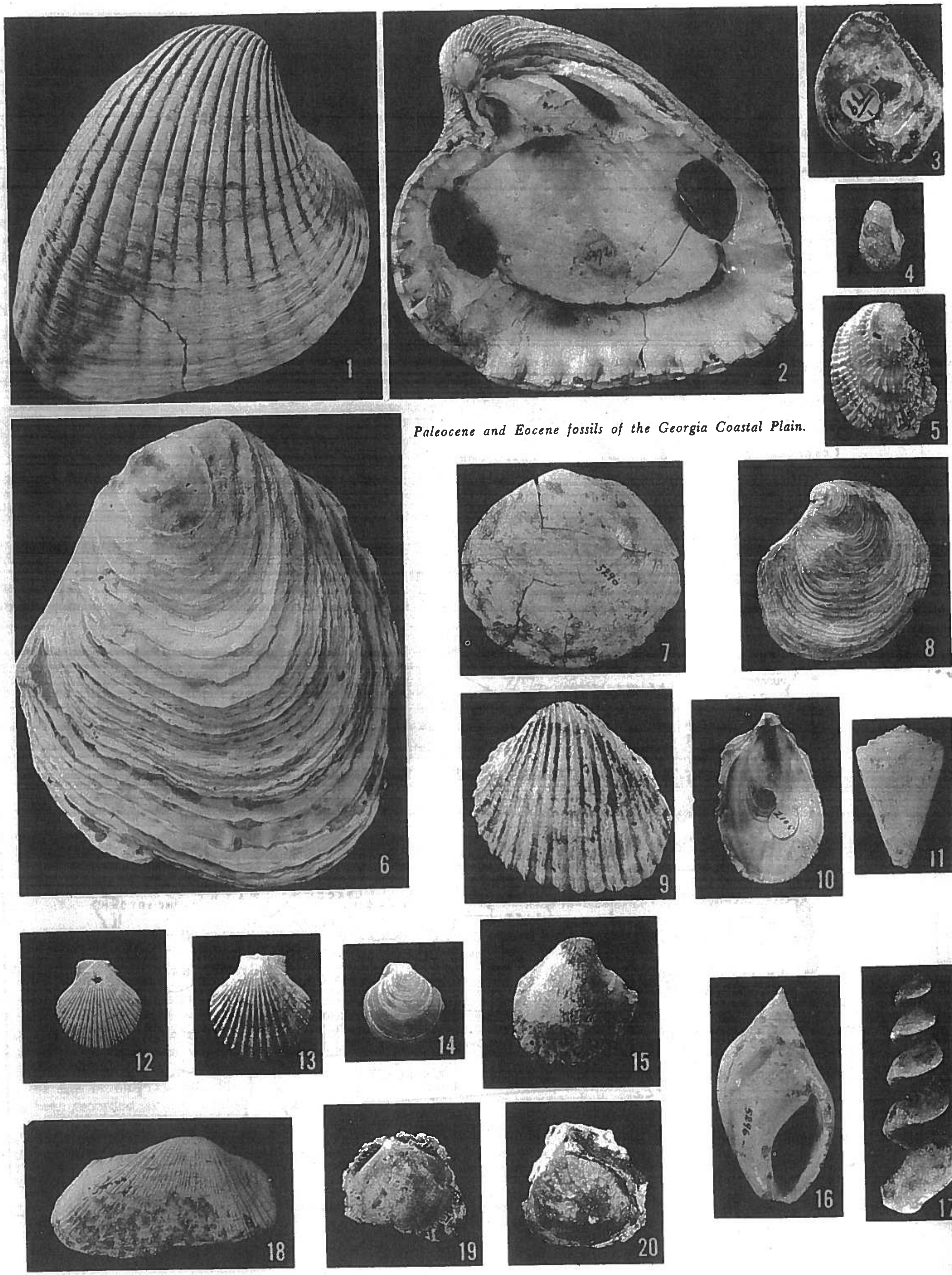
Cooke, C. Wythe and Shearer, H. K.
1918. Deposits of Claiborne and Jackson Age in Georgia. U. S. Geol. Surv. Prof. Paper 120-C.

*Foraminifera from here described and illustrated by Joseph A. Cushman and Stephen M. Herrick, 1945. *The Foraminifera of the Type Locality of the McBean Formation.* Contr. Cush. Lab. Foram. Res., Vol. 21, Pt. 3.

**Referred to as *Ostrea georgiana* in earlier literature.

Map showing outcrops of Eocene formations of Georgia





Paleocene and Eocene fossils of the Georgia Coastal Plain.

Harris, G. D.
1896. The Midway Stage. Bull. Amer. Paleont. Vol. 1, No. 4.

———
1897. The Lignitic Stage: Part I. Stratigraphy and Pelecypoda. Bull. Amer. Paleont. Vol. 2, No. 9.

———
1899. The Lignitic Stage: Part II. Scaphopoda, Gastropoda, Pteropoda and Cephalopoda. Bull. Amer. Paleont. Vol. 3, No. 11.

———
1902. Eocene Outcrops in Georgia. Bull. Amer. Paleont. Vol. 4, No. 16.

———
1919. Pelecypoda of the St. Maurice and Claiborne Stages. Bull. Amer. Paleont. Vol. 6, No. 31.

MacNeil, F. Stearns
1944. *In* Southeastern Geological Society Second Field Trip (Guide Book).

———
1947a. Geologic Map of the Tertiary and Quarternary Formations of Georgia. U. S. Geol. Surv. Oil and Gas Investigations Prelim. Map 72.

———
1947b. Correlation Chart for the Outcropping Tertiary Formations of the Eastern Gulf Region. U. S. Geol. Survey Oil and Gas Invest. Prelim. Chart 29.

Palmer, Katherine V. W.
1937. The Clairbornian Scaphopoda, Gastropoda and Dibrachiate Cephalopoda of the Southern United States. Bull. Amer. Paleont. Vol. 7, No. 32.

Rainwater, E. H.
1944. *In* Southeastern Geological Society Second Field Trip (Guide Book).

Veatch, Otto and Stephenson, L. W.
1911. Preliminary Report on the Geology of the Coastal Plain of Georgia. Georgia Geol. Surv. Bull. 26.

The Cretaceous of Georgia

by

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Academy of Natural Sciences

Philadelphia, and the University of Pennsylvania.

Part 2: Blufftown, Cusseta, Ripley and Providence formations.*

TUSCALOOSA FORMATION

Since the preparation of the article on the Tuscaloosa formation (Georgia Mineral News Letter, Spring, 1956), a new report and map of the outcropping Cretaceous formations of Georgia by Eargle (1955) have been issued by the United States Geological Survey. Some of the deposits previously mapped as Tuscaloosa are regarded by Eargle as "undifferentiated Cretaceous." He states (pp. 83-84):

> "Most of the beds of the Cretaceous section east of the Ocmulgee River are so similar that it has not been possible to map separate formations. In earlier reports the Cretaceous strata east of the Ocmulgee River have been assigned to the Tuscaloosa formation, but it now appears that only the basal part of these beds in central Georgia, possibly a few tens of feet, can properly be assigned to the Tuscaloosa formation. Most of the Cretaceous formations of the Chattahoochee region may be represented in eastern Georgia, but if so, all look so much alike that they cannot be readily differentiated."

A few additional outcrops of the Tuscaloosa are given by Eargle (pp. 8-23).

EUTAW FORMATION

A few additional outcrops of the Eutaw formation are recorded by Eargle (pp. 23-32); these are from Muscogee, Chattahoochee, Marion and Taylor counties with a few questionable localities in Crawford and Bibb counties.

A report on the macrofossils of the Eutaw and Blufftown formations of Georgia and Alabama has been prepared by L. W. Stephenson and will shortly be published by the United States Geological Survey as a Professional Paper.

BLUFFTOWN FORMATION

The Blufftown formation was named by Veatch (1909) from a village, now abandoned, on a high bluff overlooking the Chattahoochee River in Stewart County, Georgia. The formation is mainly known from Stewart, Chattahoochee and Marion counties, although Eargle maps it also in Muscogee, Taylor and Talbot counties.[1]

Veatch originally regarded the Blufftown as the lowest part of the Ripley. Veatch and Stephenson (1911) regarded it as the upper part of the Eutaw and called it the Tombigbee sand which forms the youngest part of the Eutaw in western Alabama. Stephenson and Monroe (1938) showed that the Blufftown grades westward into the lower part of the Selma chalk, while the Eutaw grades westward into the main body of the Eutaw, probably the upper part. Cooke (1943) and Eargle (1955) have summarized the work on the Blufftown formation of Georgia.

The Blufftown crops out in a belt from the Chattahoochee River east-northeast to Flint River. East of the Flint it is indistinguishable from underlying Eutaw and the overlying Cusseta sand (Eargle, 1955, p. 33.)

In Chattahoochee Valley the Blufftown formation consists of 150 feet of cross-bedded sand overlaid by 260 feet of gray micaceous carbonaceous clay with many fossils. The presence of *Exogyra ponderosa* suggests a correlation with the Black Creek of North Carolina and the Selma chalk of Alabama. A full report on the fossils will be included in the forthcoming paper by Stephenson mentioned above.

1. **Blufftown, Stewart County, Ga.** This well-known locality is at Old Blufftown Landing on the Chattahoochee River 6 miles above the town of Omaha. Fossils from this locality were mentioned by Sir Charles Lyell as early as 1846. The town site is now abandoned and can best be reached by boat although it is possible to reach it by a narrow woods path. The fossils occur in a gray calcareous, occasionally glauconitic, sand to about 120 feet above the river level. It is overlaid by non-fossiliferous slightly pebbly sand of the Cusseta formation. This locality has been described by Veatch and Stephenson (1911, pp. 134-137), Cooke (1943, p. 22) and Eargle (1955, p. 36); lists of fossils are given by the first two authors. A few of the more common species are listed below:

(Pelecypoda)
Nucula cf. *percrassa* Conrad
Breviarca umbonata Conrad
Exogyra ponderosa Roemer
Gryphaea sp.
Cucullaea sp.
Cardium dumosum Conrad
C. spillmani Conrad
Cardium sp.
Aphrodina regia Conrad?
(Gastropoda)
Turritella quadrilira Johnson
Turritella spp.

2. **Florence Landing, Stewart County, Ga.** The Blufftown formation is exposed on the Chattahoochee River at Florence Landing just west of the small settlement of that name.

3. **Omaha, Stewart County, Ga.** The Blufftown formation is exposed in the banks of Hannahatchee River near the bridge at Omaha. A few poorly preserved fossils were noted.

4. **Banks Landing, Stewart County, Ga.** Cooke (1943, p. 21) records a long list of fossils from Banks Landing, half a mile below Hichitee Creek. The locality was not visited during the present survey.

5. **Cusseta, Chattahoochee County, Ga.** Some 18 feet of coarse sand (Cusseta) overlies about 16 feet and sand and clay (Blufftown) on Highway 27 about 2.5 miles northwest of its junction with 280. (See photograph). Fossils collected from the lower part include *Exogyra ponderosa, Anomia argentaria* and *Ostrea tecticosta.*

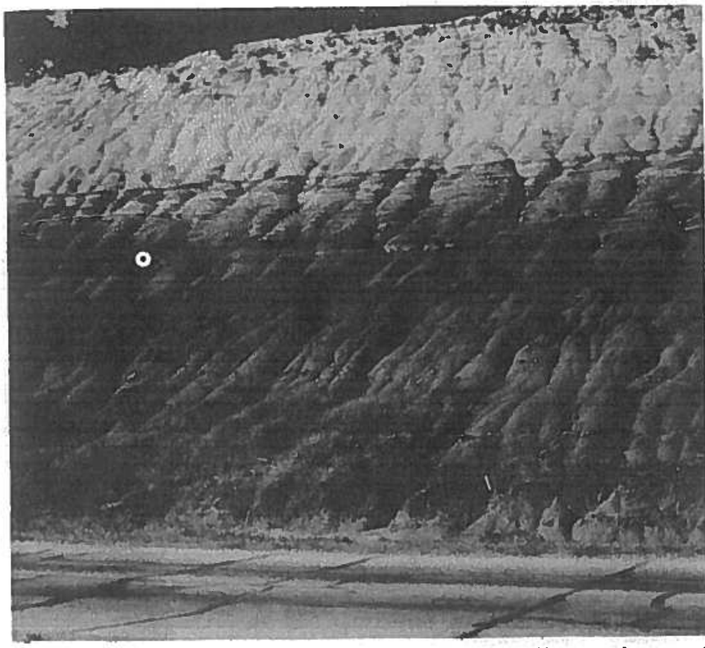
CUSSETA SAND

The name was proposed by Veatch (1909) from the town of that name in Chattahoochee County, Georgia. Veatch and Stephenson (1911) regarded the Cusseta as a member of the Ripley formation, but it was later returned to the rank of formation (Stephenson and Monroe, 1938; Cooke, 1943). The formation is best developed in the Chattahoochee Valley,

*This is the final paper in the present series on the Geology of the Coastal Plain of Georgia. The maps accompanying this article were prepared before the publication of Eargle's report and consequently do not take his observations into consideration.

but it extends northeastward to the Flint River.

The formation generally consists of cross-bedded coarse pebbly sand. The upper part is finer and contains some clay. While most of the formation is non-fossiliferous, an offshore facies containing fossils has been recognized in the Chattahoochee Valley. The contact between the Cusseta and the underlying Blufftown is not always distinct, and Eargle has redetermined as Cusseta some of the sands previously regarded as Blufftown. The Cusseta is probably equivalent to the upper part of the *Exogyra ponderosa* zone and to the upper part of the Selma chalk of Alabama.



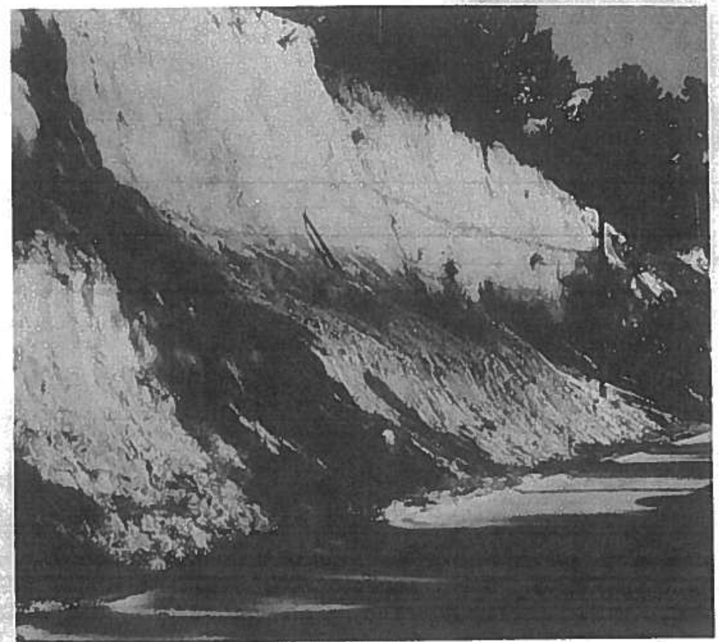
Cusseta sand overlying Blufftown formation 2.5 miles northwest of Cusseta, Georgia.

1. **Cusseta, Chattahoochee County, Ga.** Both the Cusseta and Blufftown formations are exposed on the west side of Highway 27 about 2.5 miles northwest of the junction with Highway 280. Fossils were collected from the Blufftown but none were observed in the Cusseta. See photograph.
2. **Florence, Stewart County, Ga.** The section assigned to the Cusseta by previous writers has been reassigned to the Blufftown by Eargle (1955, p. 47).
3. **Blufftown, Stewart County, Ga.** The overlying sands at this locality are correlated with the Blufftown formation. (See locality 1 under Blufftown formation.)
4. **Woolridge Landing, Barbour County, Ala.** A sandy shell marl correlated with the offshore facies of the Cusseta formation has been reported from Woolridge Landing, Alabama, 13.5 miles above Eufaula. It was not visited during the present survey. Among the fossils reported are specimens of *Exogyra ponderosa* var. *erraticostata* Stephenson (Cooke, 1943, p. 26.)

RIPLEY FORMATION

This formation was named for Ripley, Mississippi. In Georgia the formation is best developed near the Chattahoochee River although it undoubtedly extends eastward. In the Chattahoochee Valley it is usually a dark gray to black fine micaceous sand or sandy clay. Faunally the Ripley of Georgia is equivalent to the lower part of the Ripley of Mississippi and to the *Exogyra cancellata* zone and the lower part of the *Exogyra costata* zone.

1. **Eufaula, Barbour County, Ala.** The best known locality of the Ripley formation in the Chattahoochee Valley occurs



Ripley formation exposed along Highway 27, 3¾ miles north of Lumpkin, Georgia.

on the Alabama side of the river just south of the highway bridge leading to Eufaula. Here an 80 foot bluff exposes a gray to black micaceous sand with many fossils. A few are listed below:

(Pelecypoda)
Gryphaea convexa Say
Exogyra costata Say
Ostrea tecticosta Gabb
Anomia argentaria Morton
Trigonia eufaulensis Gabb
Veniella conradi (Morton)
Glycymeris sp.
Crenella serica Conrad
Vetericardia crenilirata (Conrad)
Nucula percrassa Conrad
Barbatia saffordi (Gabb)?
(Gastropoda)
Turritella sp.

2. **Lumpkin, Stewart County, Ga.** Fossiliferous Ripley sand is well exposed along the east side of Highway 27 about 3¾ miles north of Lumpkin(See photograph.) Although species are few, individuals are numerous. The following have been identified:

Exogyra costata
Gryphaea convexa
Anomia argentaria
Ostrea tecticosta
O. subspatulata

Foraminifera from this locality have been listed by Rainwater (*in* Herrick and LaMoreaux, 1944, pp. 58-59).

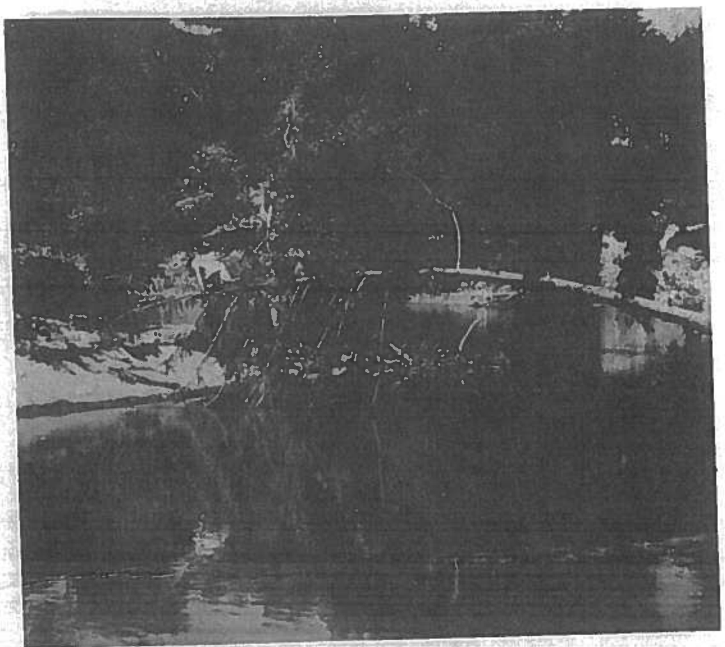
3. **Renfroe, Chattahoochee County, Ga.** Railroad cuts about ¼ mile north of Renfroe reveal fossiliferous Ripley. The following have been recorded:

Exogyra costata
E. cancellata
Gryphaea convexa
Ostrea tecticosta
Ostrea plumosa
Anomia argentaria
Paranomia scabra
Pecten sp.

Foraminifera from this locality are listed by Rainwater (*in* Herrick and LaMoreaux, 1944, p. 56).

PROVIDENCE SAND

Veatch (1909) first described the Providence sand and regarded it as part of the Ripley formation. It was more fully described by Veatch and Stephenson (1911); later it was given formational rank by Stephenson and Monroe (1938) and was so regarded by Cooke (1943). The formation is named for



Providence sand exposed at mouth of Pataula Creek, Clay County, Ga.

a small town in Stewart County, 7 miles west of Lumpkin, Georgia.

The Providence sand consists chiefly of light colored generally cross-bedded sand with lenses of light colored clay. It is non-marine in its type locality, but becomes very fossiliferous down dip, for example at Pataula Creek. Full descriptions of various aspects of this formation have recently been given by Eargle (1955).

The Providence sand is thought to be equivalent to the Prairie Bluff chalk of Alabama and Mississippi and to the Owl Creek formation of northern Mississippi (Cooke, 1943, p. 35).

1. **Providence Canyons, Stewart County, Ga.** Spectacular erosional features, more than 150 feet deep, can be seen at Providence Canyons near the headwaters of Turner Creek some 7 miles west of Lumpkin. This is the type locality of the formation and represents the up dip non-marine facies. Other similar gullies occur in the vicinity.

2. **Pataula Creek, Clay County, Ga.** About 1/4 mile above the junction of Pataula Creek and the Chattahoochee River there is an excellent outcrop of the marine facies of the Providence sand. This can be reached by driving north from Fort Gaines on Route 39 for about 10 miles to a small store on the north side of Pataula Creek, and then following a dirt road to the Chattahoochee River. Fossils are abundant and include the following:

PELECYPODA

Nucula percrassa Con.?
Breviarca cuneata (Gabb)
Glycymeris subaustralis (d'Orb)
Gryphea mutabilis Morton?
Pecten simplicius Con.
Anomia argentaria Morton
Crenella serrica Con.
Exogyra costata Say
Ostrea tecticosta Gabb
Liopistha protexta Con.
Veniella conradi (Morton)
Vetericardia crenilirata (Conrad)
Crassatella sp.
Cardium spillmani Con.
Cyprimeria depressa Con.
Corbula crassiplica Gabb
Trigonia sp.

GASTROPODA

Turritella sp.
Polinices rectilabrum (Conrad)

CEPHALOPODA

Sphenodiscus sp.
Scaphites conradi Morton

ECHINODERMATA

Hardouina subquadrata? (Conrad)?

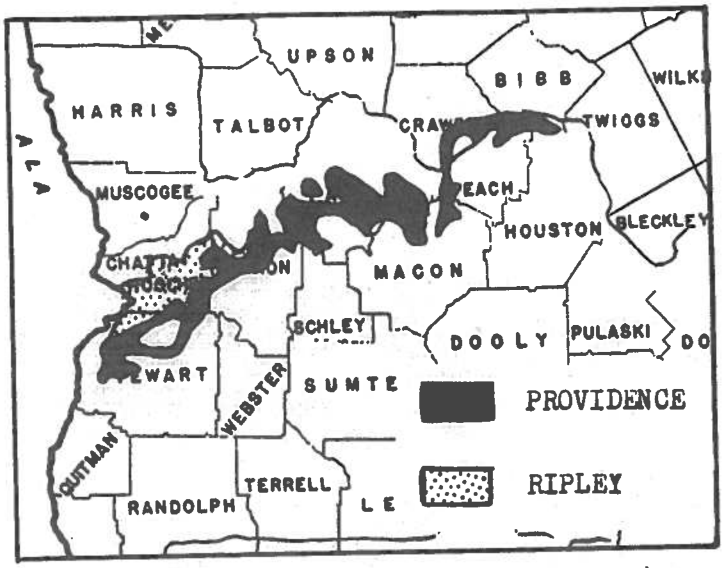
COELENTERATA

Micrabacia hildgardi Stephenson

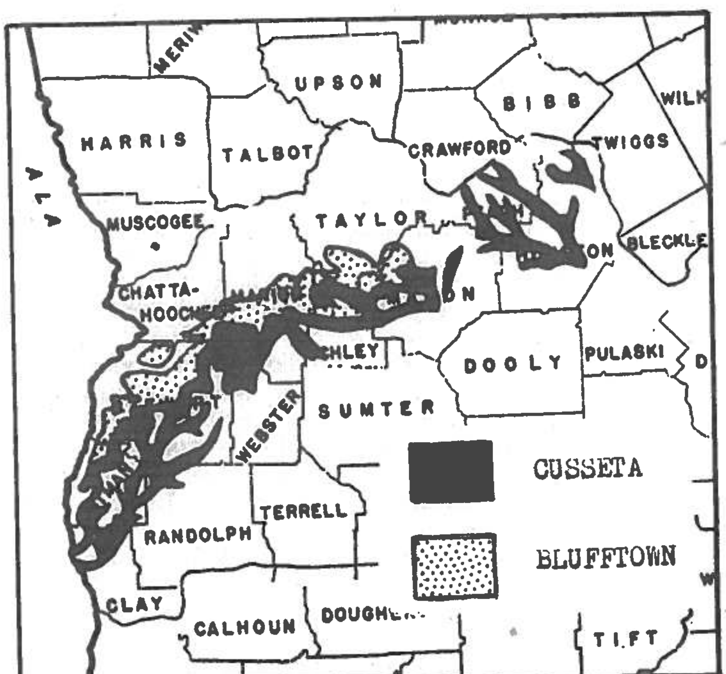
3. **"The Narrows", Clay County, Ga.** About 1/4 mile farther upstream on Pataula Creek a bed of sandstone supports a small waterfalls. Fossils are equally abundant here.

CRETACEOUS OF ALABAMA

The Upper Cretaceous deposits of Alabama have been summarized by Stephenson (1926); illustrations of typical fossils are included.



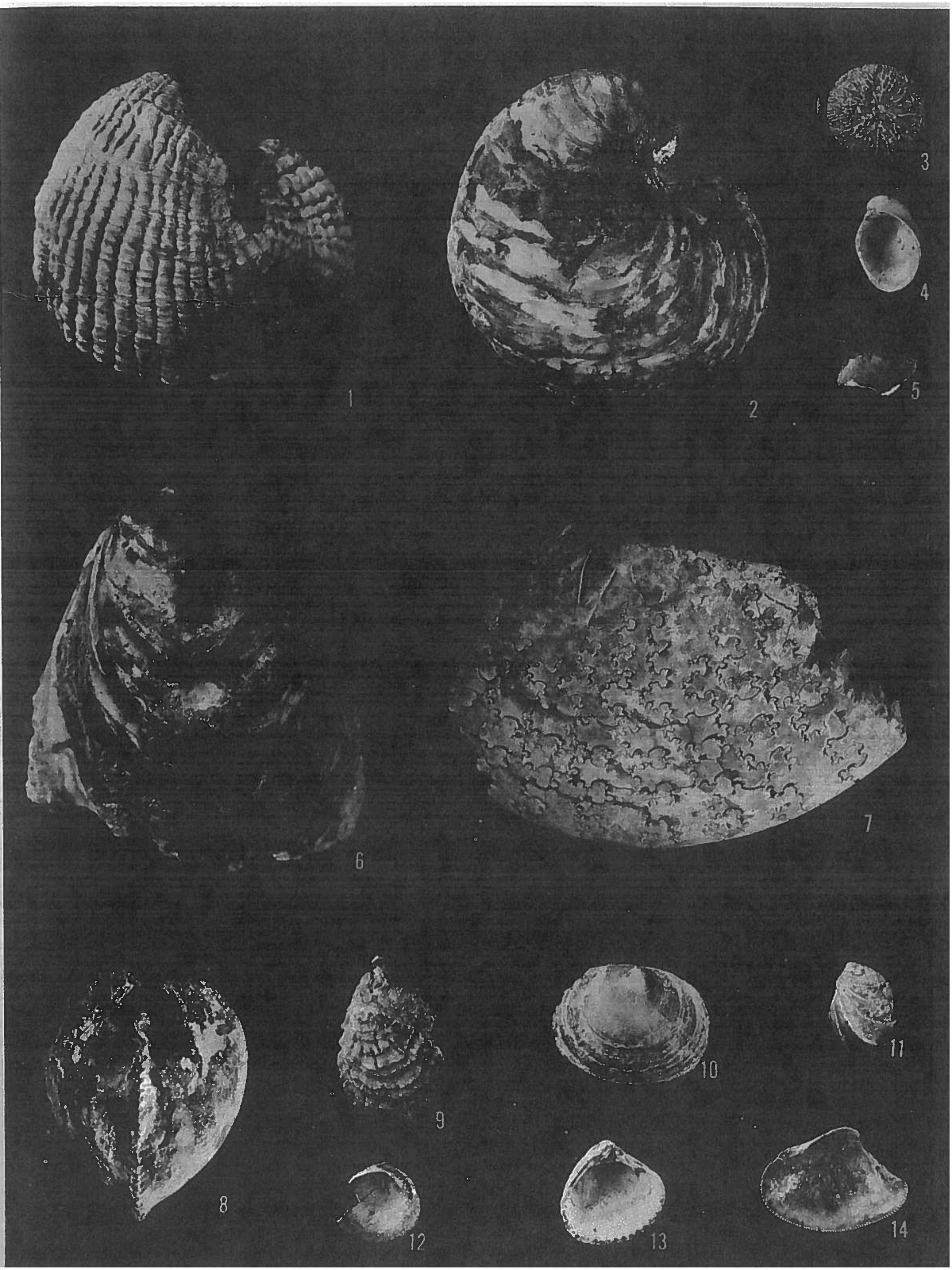
Outcrops of Cusseta and Blufftown formations in Georgia.



Outcrops of Providence and Ripley formations in Georgia.

UPPER CRETACEOUS FOSSILS
(See Illustration, 1-14)

1. *Exogyra costata* Say, 5 miles north Lumpkin, Ga. (x 1)
2. *Exogyra ponderosa* Roemer, Cusseta, Ga. (x 1)
3. *Micrabacia hilgardi* Stephenson, Pataula Creek, Ga. (x 4)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4. *Crenella serica* Conrad, Eufaula, Ala. (x 4)
5. *Nucula percrassa* Conrad, Eufaula, Ala. (x 1)
6. *Gryphaea* sp. 3¾ miles north Lumpkin, Ga. (x 1)
7. *Sphenodiscus* sp., Eufaula, Ala. (x ⅔)
8. *Cardium spillmani* Conrad, Pataula Creek, Ga. (x 1)
9. *Ostra tecticos* Gabb, 3¾ miles north Lumpkin, Ga. (x 1)
10. *Anomia argenraria* Morton, 3¾ miles north Lumpkin, Ga. (x 1)
11. *Trigonia eufaulensis* Gabb, Eufaula, Ala. (x 1)
12. *Glycymeris subaustralis* (d'Orbigny), Pataula Creek, Ga. (x 1)
13. *Vetericardia crenalirata* (Conrad)?, Eufaula, Ala. (x 4)
14. *Nucula percrassa* Conrad?, Pataula Creek, Ga. (x 4)

REFERENCES

Cooke, C. Wythe
1943 Geology of the Coastal Plain of Georgia. U. S. Geol. Surv. Bull. 941.

Eargle, D. Hoye
1955 Stratigraphy of the Outcropping Cretaceous Rocks of Georgia. U. S. Geol. Surv. Bull. 1014.

Herrick, S. M. and
LaMoreaux, P. E.
1944 Upper Cretaceous Series [of Georgia]. Southeastern Geol. Soc. Guidebook of Second Trop., pp. 6-20.

Rainwater, E. H.
1944 *in* Herrick and LaMoreaux.

Stephenson, L. W.
1926 The Mesozoic Rocks [of Alabama]. *in* "Geology of Alabama." Alabama Geol. Surv. Bull. 14, pp. 231-251.

Stephenson, L. W. and
Monroe, Watson
1938 Stratigraphy of Upper Cretaceous Series in Mississippi and Alabama. Bull. Amer. Assoc. Petrol. Geol. Vol. 22, pp. 1639-1657.

Veatch, J. O.
1909 Second Report on the Clay Deposits of Georgia. Georgia Geol. Surv. Bull. 18.

Veatch, J. O. and
Stephenson, L. W.
1911 Preliminary Report on the Geology of the Coastal Plain of Georgia. Georgia Geol. Surv. Bull. 26.

The Cretaceous of Georgia

Part 1: Lower Cretaceous, Tuscaloosa and Eutaw formations.

by

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Philadelphia, Pa.[1]

LOWER CRETACEOUS

No outcrops of Lower Cretaceous rocks are known from Georgia. On the other hand some non-marine sands and clays of probable Early Cretaceous age have been found in several oil tests in Early, Mitchell, Atkinson and Wayne Counties. (Applin and Applin, 1947; Richards, 1948). (See Diagram). Apparently the Early Cretaceous seas did not cover Georgia although they extended over parts of Alabama and southern Florida.

UPPER CRETACEOUS

Tuscaloosa Formation

The Tuscaloosa formation was named in 1887 for the city of that name in Alabama. The deposits now called Tuscaloosa in Georgia were regarded as Lower Cretaceous by Veatch and Stephenson (1911), but later they were correlated with the Tuscaloosa of Alabama (Berry, 1923, Cooke, 1926, 1943), largely on the basis of fossil plants.

The Tuscaloosa formation crops out as an irregular band along the Fall Line, although in places it overlaps the Piedmont Province. (See map). In general, the formation consists of arkosic sand with lenses of clay or sandy clay. Occasionally it is cemented to a sandstone. The name "Middendorf formation" was formerly used for the extension of this formation into South Carolina, but the name Tuscaloosa is now accepted.

Along its outcrop, the Tuscaloosa formation is usually less than 600 feet in thickness; however, downdip, it is much thicker, possibly being as thick as 2600 feet in Dougherty County. In outcrop, the Tuscaloosa formation is entirely non-marine. However, it is apparent that the sea covered a portion of the Georgia Coastal Plain during part of Tuscaloosa time because of the finding of marine fossils, mainly foraminifera and mollusks, in various wells, especially near Albany, Dougherty County; (Richards, 1945, 1948). Among the species reported from the Sealy Well near Albany, are the pelecypods *Ostrea paytoni, Pecten sealeyi,* and the Annelid *Hamulus howelli,* all described by Richards (1947).

The only fossils known from the outcrops of this formation in Georgia are a few leaves found at McBride Ford, Upatoi

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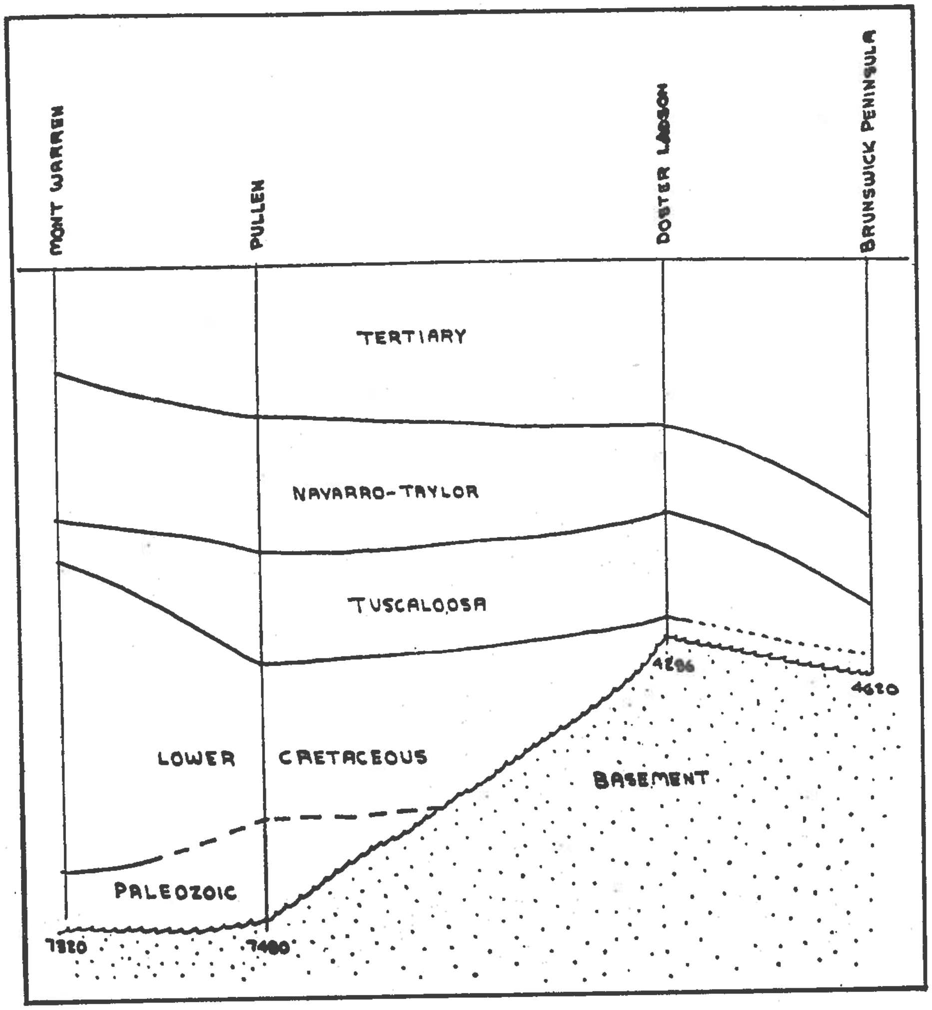
[1]Also University of Pennsylvania

Map showing outcrops of Tuscaloosa and Eutaw formations in Georgia.



Generalized east-west cross-section on the Coastal Plain of Georgia connecting the Mont Warren well, 3 miles southwest of Cedar Springs, Early County; Stanolind's Pullen well, 10 miles southeast of Camilla, Mitchell County; Sun Oil Company's Doster-Ladson, 6.6 miles southwest of Pearson, Atkinson County; California Company's Brunswick Peninsula well, 6.8 miles east of McKinnon, Wayne County. Vertical scale 1 inch = 2400 feet; horizontal scale 1 inch = 32 miles. (After Richards, 1948). See map location of section.

Creek, 4.5 miles upstream from the Cusseta Road. These were identified by E. W. Berry and cited by Veatch and Stephenson (1911, p. 128). This outcrop was then correlated with the Eutaw formation, but is now believed to be in the Tuscaloosa (Cooke, 1943, p. 9). The list of species is as follows:

Andromeda cretacea Lesq.?
Andromeda wardiana Lesq.
Androvettia elegans Berry.
Brachyphyllum macrocarpum Newberry.
Cinnamomum newberryi Berry
Cinnamamum heeri Lesq.
Aralia eutawensis Berry
Eucalyptus angusta Valen.
Ficus ovatifolia Berry
Juglans artica Heer?
Magnolia boulayana Heer.
Magnolia capellinii Heer.
Manihotoides georgiana Berry.
Menispermites variabilis Berry.
Paliurus upatoinsis Berry.
Salix flexuosa Newberry.
Sequoia reichenbachi (Geinitz) Heer.
Tumion carolinianum Berry?
Zizyphus laurifolius Berry.

The Tuscaloosa formation is approximately equivalent to the Eagle Ford or Woodbine of Texas and the Raritan of New Jersey. In the subsurface from New Jersey to South Carolina it is characterized by the pelecypod *Exogyra woolmani* Richards.

1. *Dry Branch, Twiggs County, Ga.* White kaolin of the Tuscaloosa formation is dug from the pits of the Georgia Kaolin Company, 3 miles east of Dry Branch. The Tuscaloosa is here overlaid by the Barnwell formation. (See Locality 6 p. 151, Ga. Mineral Newsletter, Winter, 1955).

The kaolin is used extensively for commercial purposes, especially for the manufacture of coated paper and rubber.

2. *Near Macon, Bibb County, Ga.* Mottled Tuscaloosa clay overlies schist along Route 80, three to five miles west of Macon.

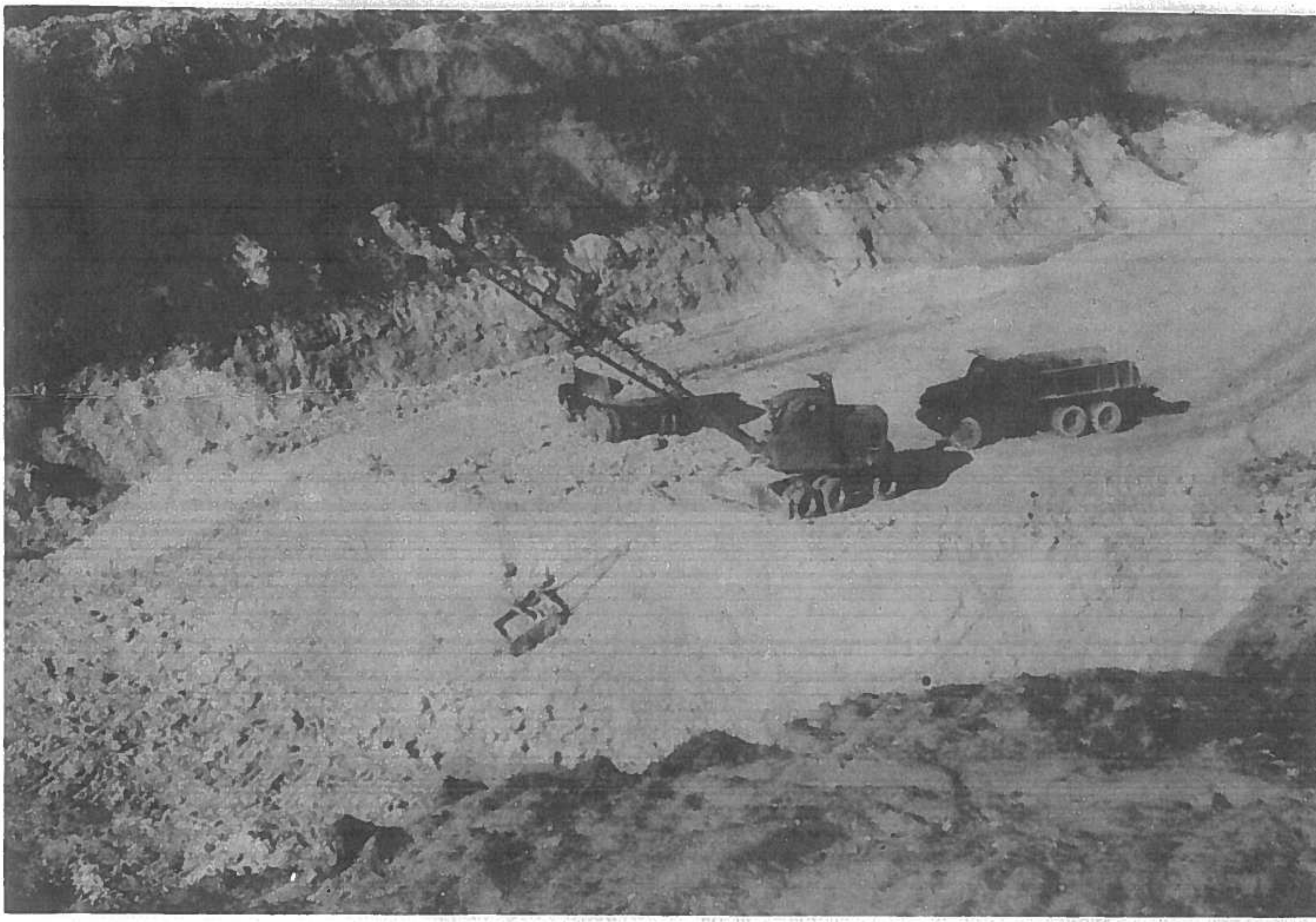
3. *Rich Hill, 4 miles southeast of Knoxville, Crawford County, Ga.* White micaceous clay of the Tuscaloosa formation underlies the Ocala limestone in road cuts at Rich Hill. (See Locality 6 p. 155, Ga. Min. Newsletter, Winter, 1955).

Atkinson Formation

Applin and Applin (1947) proposed the new Atkinson formation for all pre-Austin Upper Cretaceous beds in the subsurface of Alabama, Georgia and north Florida. The formation is equivalent to the Tuscaloosa formation of the outcrop plus the lower part of the Eutaw formation, recently described as the McShand formation in Alabama by Monroe, Conant and Eargle (1946). The type locality of the Atkinson formation is the Sun Oil Company's Doster-Lodson well in Atkinson County, Georgia. Three subdivisions of the Atkinson were recognized by the Applins, but merely designated as lower, middle and upper. While the Atkinson formation has been accepted by the United States Geological Survey, some writers continue to use the terms Tuscaloosa and Eutaw at least for surface exposures. (Richards, 1948, Eargle, 1953).

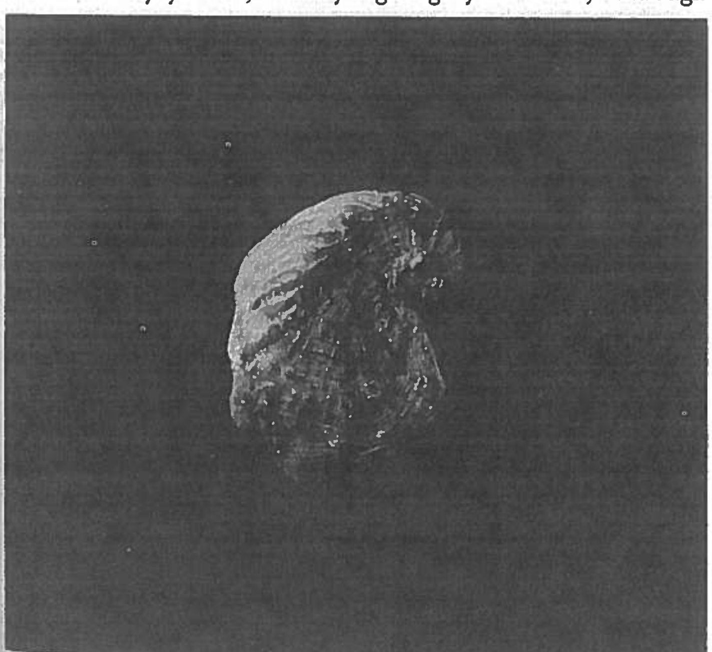
Eutaw Formation

The Eutaw formation was named for a town of that name in Alabama. It extends eastward into Georgia across Chattahoochee County into Marion County where it is overlapped



Pits of Georgia Kaolin Company at Dry Branch, Georgia. The Barnwell formation overlies the kaolin of the Tuscaloosa formation.

by the Cusseta sand. There are also a few outliers in Muscogee County. (See map). The material is predominately sand or clayey sand, usually light gray in color, although



Exogyra upatoiensis Stephenson, an index fossil of the Eutaw formation.

weathered surfaces are rusty brown. In Georgia, only the upper part of the Eutaw formation is exposed. This is equivalent to the Tombigbee sand member of Alabama. In outcrop, it is approximately 100 feet in thickness, although it is as much as 420 feet thick in wells. The Eutaw is probably roughly equivalent to the Middle Austin of Texas and the Magothy of New Jersey and Maryland.

The Eutaw formation lies unconformably on the Tuscaloosa and is unconformably overlaid by the Blufftown. The Eutaw is predominately marine and is characterized by the pelecypod *Exogyra upatoiensis* Stephenson as well as a few other species.

1. *Upatoi Creek, 7 miles southeast of Columbus, Chattahoochee County, Ga.* The Eutaw formation is well exposed along Route 27 0.5 miles south of the crossing of Upatoi Creek. The material is largely sand but there are some streaks of clay; locally the sand is indurated to sandstone. Indistinct fossils can be obtained including the following genera: Arca, Ostrea, Cardium, Nuculana and Pedalion?. *Exogyra upatoiensis* has been obtained here, but was not observed during the field work of 1954.

2. *Ochilee, Chattahoochee County, Ga.* Sand and calcareous sandstone of the Eutaw formation can be seen in the stream bed of Ochilee Creek beneath the highway bridge near the town of Ochilee. The fossils are poorly preserved, but the following have been recognized: *Nucula* sp., *Ostrea cretacea* Morton, *Anomia olmstedi* Stephenson, *Etea* sp., *Cyprimeria depressa* Conrad?, *Leptosolen biplicata* Conrad, *Corbula oxynema* Conrad. (Cooke, 1943, p. 16).

Various other exposures of the Eutaw formation can be seen along the Chattahoochee River below Columbus, on both the Georgia and Alabama sides, especially at Broken Arrow Bend on the left bank 10.5 miles below Columbus. Mollusks, shark teeth and plants have been reported. (Veatch and Stephenson, 1911, pp. 118-119). The formation is also exposed at various localities in Fort Benning, but no fossils were observed.

REFERENCES

Applin, Paul and
Applin, Esther
1947 Regional Subsurface Stratigraphy, Structure and Correlation of Middle and Early Upper Cretaceous Rocks in Alabama, Georgia and North Florida. U.S. Geol. Surv. Oil and Gas Invest. Prelim. Chart 26.

Berry, E. W.
1923 The Age of the Supposed Lower Cretaceous of Alabama. Jour. Wash. Acad. Sci. Vol. 13, pp. 433-435.

Cooke, C. Wythe
1926 Correlation of the Basal Cretaceous Beds of the Southeastern States, U.S. Geol. Surv. Prof. Paper 140.

———
1943 Geology of the Coastal Plain of Georgia. U.S. Geol. Surv. Bull. 941.

Eargle, D. Hoye
1953 The Outcropping Cretaceous Rocks of Georgia. Georgia Dept. Mines, Mining and Geology. Bull. 60, pp. 1-20.

Monroe, Watson,
Conant, L. C. and
Eargle, D. H.
1946 Pre-Selma Upper Cretaceous Stratigraphy of Western Alabama. Bull. Geol. Soc. Amer. Vol. 30, pp. 187-212.

Richards, Horace G.
1945 Subsurface Stratigraphy of Atlantic Coastal Plain between New Jersey and Georgia. Bull. Amer. Assoc. Petrol. Geol. Vol. 29, pp. 885-955.

———
1947 Invertebrate Fossils from Deep Wells Along the Atlantic Coastal Plain. Jour. Paleont. Vol. 21, pp. 23-37.

———
1948 Studies on the Subsurface Geology and Paleontology of the Atlantic Coastal Plain. Proc. Acad. Nat. Sci. Phila. Vol. 100, pp. 39-76.

Veatch, Otto and
Stephenson, L. W.
1911 Preliminary Report on the Geology of the Coastal Plain of Georgia. Georgia Geol. Surv. Bull. 26.